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Technology, Common Inputs, And Public Policies In Developing Countries

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by

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Abstract

The thesis consists of three essays. In the first essay, a two-final-good and knowledge-based growth model is built to study the patterns of economic growth in a SOE. The source of economic growth is the introduction of new intermediate goods as a result of R&D, which in turn generates dynamic IRS in both the production of one final good and R&D. The results obtained in the model are consistent with intercountry differences in growth patterns.

The second essay constructs a simple model to study how technology transfer (through foreign direct investment or licensing of technology) affects R&D intensity of domestic firms in LDCs. We have shown that both foreign direct investment and licensing of technology have a negative effect on domestic R&D intensity in host country. We also study implications from some technology policies.

The third essay models the rent-seeking behaviour in the process of the allocation of public intermediate goods among different sectors, which may be one important factor for understanding sectoral development in LDCs. By using a full-employment general equilibrium model, we also study how other policies affect the lobbying intensities by different interest groups and hence the allocation of public intermediate goods. We also discuss the misallocation of resource in the presence of this kind of rent - seeking behaviour.

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Any errors or omissions are my sole responsibility.

Contents

Chapter 1

Dynamic Increasing Returns, Technology, and Economic Growth in a Small Open Economy

1.1 Introduction

A two-sector neoclassical framework has been adopted to study relationships between trade and economic growth in a number of works.[1] In the neoclassical framework, however, economic growth sometimes crucially depends on some exogenous parameters, such as exogenous technological progress and an exogenous saving rate. Moreover, it has been pointed out that the neoclassical framework cannot satisfactorily explain many empirical phenomena, such as the diversity in per capita GDP growth rates across countries and the lack of negative correlation between income levels and growth rates.[2]

Recently, knowledge-based growth models have been developed to overcome the above criticism in the area of macroeconomics in response to the thrust generated by Romer (1986) and Lucas (1988). In those frameworks, cumulative knowledge plays an important role in generating endogenously determined and sustained growth. Those models primarily evaluate a closed economy with only one final good. The purpose of this essay is to provide a growth model of a multiple-sector, small open

[1]Findlay (1984) and Smith (1984) survey this literature.
[2]Romer (1986) discusses these empirical results.

economy (SOE) in the context of knowledge-based growth. In particular, we are concerned with the observation that the patterns of economic growth are quite different across countries [see Lucas (1988)]. We wonder why some economies, such as South Korea and Taiwan, have been growing successfully, while numerous others have not. This essay tries to construct a model consistent with this observation.

The specific features of our model are as follows. There are two primary factors, labor and land. In addition to two final-good sectors (X and Y), we introduce two more sectors into the model: the R&D sector and the intermediate-good sector.[3] Good Y is produced under constant returns to scale (CRS) with labor and a specific factor, land. Good X is produced with differentiated intermediate goods alone with a CRS, CES production function, and the intermediate goods are in turn produced with labor alone, provided the technology is available. Monopolistic competition prevails in the intermediate-good market. The number of producible intermediate goods can be augmented as a result of R&D.

The above relationship between good X and the differentiated intermediate goods generates IRS in the production of good X. Using a CES production function, Ethier (1982) originally introduces the Dixit and Stiglitz (1977) type of differentiated intermediate goods into a static general equilibrium framework to provide a micro-foundation of Marshallian external economies.[4] In the present study, a R&D sector is introduced into his framework to construct a dynamic framework with IRS. Insight from Romer (1988) is borrowed to set up this R&D sector. The productivity of labor in R&D crucially depends on the cumulative knowledge in the R&D sector. The source of economic growth in this essay is the introduction of new intermedi-

[3]The two-sector neoclassical growth models commonly assume that one sector produces a consumption good and the other produces an investment good. In our model, however, both final-good sectors produce consumption goods.

[4]Ethier (1982) analyzes the positive issues in trade theory. Markusen (1988, 1989) uses the same framework to study the welfare implications of trade in services and migration. Okuno-Fujiwara (1988) provides an alternative micro-foundation by using a Cournot concept in the presence of imperfect competition.

ate goods as a result of R&D, which in turn generates dynamic IRS in both the production of good X and R&D.

Three interesting results are obtained in the model. First, we have two kinds of equilibria: a low-level equilibrium and a high-level equilibrium. In the low-level equilibrium, the economy does not grow at all (i.e., the low-level equilibrium is in fact a zero-growth equilibrium), while in the high-level equilibrium, the economy continues to grow. Depending on the initial stock of knowledge in the R&D sector, or the initial technology level, either a zero-growth equilibrium or a high-level equilibrium appears. It should be noted that we do not have multiple equilibria.[5] The initial technology level uniquely determines the equilibrium in our model. Also different technology levels lead to different income levels. Thus, the technology level is crucial in determining both levels and growth rates of per capita income.

It is also shown that the growth rate increases in the process of economic growth. This result is consistent with Romer's (1986) work. Romer (1986) discusses empirical support of the increasing growth rate and shows its possibility in a 1-final-good economy with IRS. The above results are consistent with the observed diversity across countries in both levels and rates of growth of per capita income.

Second, there exist temporary policies that move the economy from a low-level equilibrium to a high-level equilibrium to initiate economic growth. It would be interesting to compare policies such as taxes and subsidies, and derive the optimal level of subsidy or tax. However, there are at least two difficulties associated with this exercise. Since the present study does not deal with a steady state, it is difficult to evaluate these policies. Moreover, there are two distortions in our model: externalities in R&D and monopolistic competition in the intermediate-good market, which make the ranking of policies difficult. Because of these two distortions,

[5] Markusen (1988), Matsuyama (1989), and Murphy et al. (1989) also analyze the possibility of a low-level and a high-level equilibrium in different frameworks. In contrast with our model, they have multiple equilibria.

a growth enhancing policy may not necessarily be a welfare improving policy [see also Grossman and Helpman (1989c)]. In particular, permanent rather than temporary policies will be needed to achieve the first-best equilibrium. Thus, we focus on positive aspects of temporary policies in our study.[6]

Third, the labor force is reallocated from the Y sector to the R&D and the intermediate good sector in the process of economic growth. Thus, the portion of good X in the value of the total final goods can increase in the process of economic growth. This change obtained in our model can be consistent with the observation by Kuznets (1957) and Chenery (1960) that the manufactured product in the composition of output mix increases as per capita income increases.

Our framework is similar to those in Grossman and Helpman (1989b,c). In particular, using a SOE framework, Grossman and Helpman (1989c) study various policy implications on growth and welfare.[7] They also assume two primary factors, two final goods, differentiated intermediate goods, and R&D in their model. Differentiated intermediate goods are inputs for the production of *both* final goods and hence the productivity increases in both final-good sectors. They focus on a steady state and both final-goods sectors grow at the same rate in the steady state. Thus, their steady state analysis cannot generate the above three results that we obtained. Instead, the steady state analysis allows the derivation of the welfare implications

[6] Matsuyama (1989) also discusses the role of government policy in moving the economy from a low-level equilibrium to a high-level equilibrium in a dynamic framework, though there is no endogenous growth in his model. He also discusses only second-best policies that may bring out a high-level equilibrium.

[7] There are two other related works that also adopt knowledge-based growth frameworks with an emphasis on human capital accumulation to examine interactions between international trade and economic growth. Lucas (1988) uses a 2-final-good model in which the productivity of each final good depends on the level of the stock of sector-specific human capital. This sector-specific human capital is accumulated by learning by doing at a sector-specific rate. In a global trade equilibrium, each country specializes in the production of one final good. In his model, both the growth rate and the effect of trade policy crucially depend on the type of specialization that is determined by the endowments of sector-specific human capital. Manning (1982) studies the optimal educational and trade policies for a SOE by introducing an education sector and assuming the heterogeneity of the labor force (skilled and unskilled laborers). By solving the planner's problem, he shows that specialization is the most likely pattern of production. In the present model, it is shown that complete specialization is a special case in which the initial technology level is not sufficiently high.

of R&D subsidies and trade policies. Even in their analysis, however, they cannot rank those policies because of the two distortions mentioned above.

The remainder of this essay is organized as follows. Section 2 describes the basic model. In Section 3, economic growth in a multiple-sector, SOE is analyzed. It is shown that the technology level is a key to determine a dynamic path. The condition for zero-growth is derived and then, in Section 4, corresponding policies are discussed. An exogenous increase in labor is also analyzed. Section 5 discusses conclusions from the analysis.

1.2 The Basic Model

We examine a SOE with two primary factors (labor (L) and land (T)), differentiated intermediate goods ($S(i)$), know-how or technology (N) to produce intermediate goods, and two final goods (X and Y). The endowments of primary factors are fixed and normalized to be equal to one over time. Production, trade, and consumption occur instantaneously. The SOE trades final goods at exogenously given prices and has access to the world capital market at an exogenously given instantaneous interest rate. Letting good X be the numeraire, the world price of good Y is P^* and the world instantaneous interest rate is r. For simplicity, both P^* and r are assumed to be positive and fixed over time.

In the spirit of Jensen and Thursby (1986), Romer (1988), and Grossman and Helpman (1989b,c), we assume that new technology or know-how to produce new intermediate goods can be innovated in the R&D activity with labor alone and that the productivity of labor in R&D depends on the cumulative experience or knowledge in R&D. Knowledge is created as a byproduct in the process of R&D. It is assumed that knowledge is purely external to any firms in the R&D sector. That is, once knowledge is created, it immediately becomes a public good which ought to be freely available. Specifically, a flow of know-how (technology), $\dot{N}$, is formed by:[8]

$$\dot{N} = \delta N L_n, \tag{1.1}$$

where a dot over a variable denotes the derivative with respect to time, t, δ is a positive productivity parameter, and L_n is labor allocated to the R&D sector. N measures the cumulative knowledge or experience in R&D, to which the labor productivity is directly proportional. It should be noted that the cumulative knowledge is given at any point in time and thus the production function (1.1) exhibits CRS at any point in time. The R&D sector is assumed to be competitive so that the wage rate, W_n, and the price of know-how, P_n, are related in the following way:

$$W_n = \delta N P_n. \tag{1.2}$$

It is assumed that each intermediate good is produced by a single firm and that the production of any intermediate good requires know-how and labor. At any point in time t, the type of technology used by the intermediate-good sector is indexed by $i \in [0, N(t)]$. Each i corresponds to a particular type of technology to produce a particular type of intermediate good. Thus, N also measures the variety of intermediate goods. The number of producible intermediate goods can be augmented as a result of R&D. The assumption is that the producer of $S(i)$ must pay a sunk cost, P_n, to obtain know-how from the R&D sector. Once the sunk cost is incurred, he/she can produce any amount of $S(i)$ at each point in time.[9] We further assume that one unit of labor can produce one unit of $S(i)$.

Good Y is produced under CRS with labor and a specific factor, land;

$$Y = F(L_y, T) = F(L_y, 1) \equiv f(L_y); \quad f' > 0, \quad f'' < 0, \quad \lim_{L_y \to 0} f' = \infty, \tag{1.3}$$

[8]Romer (1988) and Grossman and Helpman (1989b,c) adopt the same function in R&D. Jensen and Thursby (1986) and Schmitz (1987) also assume similar functions in R&D. All variables depend on time, but we suppress the t-variables when no confusion is caused by doing so.

[9]As Grossman and Helpman (1989b) note, we can consider that R&D produces "blueprints" which are perfectly appropriable by the originator.

where L_y is the labor employment in the Y sector. Thus, the wage rate in the Y sector, W_y, and the rental rate, R, are, respectively, given by

$$W_y = Pf'(L_y), \tag{1.4}$$

$$R = P[f(L_y) - L_y f'(L_y)], \tag{1.5}$$

where P is the price of good Y.

For simplicity, good X is assumed to be produced with intermediate goods alone.[10] To make the model tractable, the $S(i)$'s are assumed to be symmetric but imperfect substitutes in the production of good X. Specifically, the production function is given by the following CRS, CES function:

$$X = \left(\int_0^N S(i)^\beta di\right)^{1/\beta}, \quad 0 < \beta < 1. \tag{1.6}$$

As is discussed in Grossman and Helpman (1989b), this production function has important characteristics. First, with a given variety of available intermediate goods, the production function exhibits CRS and hence there exists no problem with the aggregation of the individual firm outputs. Second, augmentation of the variety of available intermediate goods increases the total factor productivity. Thus, good X is produced under dynamic IRS in the presence of R&D activity. However, these economies of scale are at the sector level and are external to the individual producers.

In this model, as in Grossman and Helpman (1989b,c), and Markusen (1989), it is assumed that all agents, other than the intermediate-good suppliers, take their input and output prices as given and that monopolistic competition prevails in the intermediate-good market. The monopolistic-competition equilibrium can be solved as follows. The demand for a particular intermediate good, $S(i)$, is obtained from the following maximization problem of the producer of good X;

[10] Ethier (1982) and Markusen (1989) also make the same assumption.

$$\max_{S(i)}[(\int_0^N S(j)^\beta dj)^{1/\beta} - \int_0^N P_s(j)S(j)dj],$$

where $P_s(i)$ is the price of intermediate good $S(i)$. Noting that the producer of $S(i)$ takes $P_s(j)$ $(i \neq j)$ as given in monopolistic competition, we obtain the following inverse demand function from the first-order condition:

$$P_s(i) = [\int_0^N S(j)^\beta dj]^{\frac{1}{\beta}-1} S(i)^{\beta-1} = X^{1-\beta} S(i)^{\beta-1}. \tag{1.7}$$

A continuum of intermediate goods implies that the variety of intermediate goods is so large that each intermediate-good producer views the output of good X as given. Taking W_s and X as given, the producer of $S(i)$ who has already paid the sunk cost faces the following maximization problem;

$$\pi(i) \equiv \max_{S(i)}[P_s(i)S(i) - W_s S(i)], \tag{1.8}$$

where W_s is the wage rate in the intermediate good sector. Since the producer is a monopolistic supplier of $S(i)$, he/she maximizes profit subject to equation (1.7) and then the first-order condition implies:

$$W_s = \beta[\int_0^N S(j)^\beta dj]^{\frac{1}{\beta}-1} S(i)^{\beta-1}. \tag{1.9}$$

In the equilibrium, the intertemporal zero-profit condition holds with free entry by entrepreneurs in R&D activity. That is, free entry into R&D ensures that the sum of the discounted stream of $\pi(i)$ equals the sunk cost, P_n. With an assumption of perfect foresight, the following zero-profit condition holds at every point in time:

$$\int_t^\infty e^{-r(z-t)} \pi(i, z) dz = P_n(t), \tag{1.10}$$

which, by taking the derivative with respect to time, implies:

$$P_n r = \pi(i) + \dot{P}_n.$$

Using equation (1.2), this can be rewritten as follows;

$$\pi = \frac{W_n}{\delta N}(r - \frac{\dot{W}_n}{W_n} + \frac{\dot{N}}{N}). \tag{1.11}$$

This structure of our model leads to a symmetric monopolistic-competition equilibrium; that is, all $S(i)$'s and all $P_s(i)$'s are the same across i. Thus, we can rewrite equations (1.[illegible]), (1.7) and (1.9) as follows (we delete index i from equations):

$$X = N^{\frac{1}{\beta}} S, \tag{1.12}$$

$$P_s = N^{\frac{1}{\beta}-1}, \tag{1.13}$$

$$W_s = \beta N^{\frac{1}{\beta}-1}. \tag{1.14}$$

Thus, equation (1.8) becomes

$$\pi = (1-\beta) N^{\frac{1}{\beta}-1} S, \tag{1.15}$$

From equations (1.14) and (1.15), we obtain:

$$S = \frac{\beta \pi}{(1-\beta) W_s}. \tag{1.16}$$

Recalling that one unit of labor produces one unit of S and that there are N varieties, the labor employment in the intermediate-good sector, L_s, is:

$$L_s = SN. \tag{1.17}$$

Thus, from equations (1.12) and (1.17), the production function of good X is reduced to:

$$X = N^{\frac{1}{\beta}-1} L_s. \tag{1.18}$$

We assume full employment of labor and free mobility of labor across sectors. Then, from equations (1.2), (1.4) and (1.14), the following equations hold in an interior equilibrium:

$$W_y = Pf' = W_s = \beta N^{\frac{1}{\beta}-1} = W_n = P_n \delta N \equiv W, \tag{1.19}$$

$$L_y + L_s + L_n = 1. \tag{1.20}$$

Appendix A shows the derivation of the following equation [11]:

$$L_s = \frac{\beta r}{\delta(1-\beta)} - \frac{1-2\beta}{1-\beta} L_n. \tag{1.21}$$

Thus, changes in the labor allocation between the R&D sector and the intermediate-good sector crucially depend upon the value of β. Substituting equation (1.20) into (1.21), we derive:

$$1 - L_y = \frac{\beta r}{\delta(1-\beta)} + \frac{\beta}{1-\beta} L_n, \tag{1.22}$$

which shows that L_y and L_n are negatively correlated. From equation (1.21) and (1.22), we find that if $0 < \beta < 1/2$ and if L_y decreases, L_n rises while L_s falls. It should be noted, however, that the economy with $L_n > 0$ and $L_s = 0$ cannot be supported because there is no demand for R&D with $L_s = 0$. Appendix B shows that if $0 < \beta \leq \delta/(r + 2\delta)$, L_s can be zero at some point in time. Thus, in the following analysis, we focus on the case where $\delta/(r + 2\delta) < \beta < 1$.

If the SOE produces X, Y, and know-how under free trade, we can solve for L_y, L_s, and L_n, and thus X, Y, and $\dot{N}$ from $P = P^*$ and equations (1.19-1.21). We summarize the above argument in the following lemma;

Lemma 1.1 *As the labor employment in the Y sector falls, the labor employment in the R&D sector rises. If $\beta = 1/2$, the labor employment in the intermediate good sector is constant over time. If $1/2 < \beta < 1$ ($\delta/(r + 2\delta) < \beta < 1/2$), the labor employment in the intermediate-good sector rises (falls) as the labor employment in the Y sector falls.*

Moreover, equation (1.21) leads to

Lemma 1.2 *With equation (1.19) and $L_n = 0$, the labor allocation to the intermediate good sector is $L_s = \beta r/\delta(1 - \beta)$, which is independent of N and constant.*

[11]the following analysis, we assume that $\beta r/\delta(1 - \beta) < 1$.

1.3 Economic Growth in a Small Open Economy

In this section, we analyze the patterns of economic growth and the evolution of the sectoral composition of output in the development process. We assume that, at time $t = 0$, a SOE is established with $N(0)$. Factor income (FI), which consists of the wage and the rent on land in terms of the final good is used as an index of economic growth.[12] Since the prices of final goods (consumption goods) are exogenously given and fixed for the SOE, it is obvious that economic welfare improves as FI increases. From equations (1.4) and (1.5), FI in terms of good Y, I_y, is given by:

$$I_y = (1 - L_y)f'(L_y) + f(L_y). \tag{1.23}$$

Differentiating this equation with respect to L_y, we obtain:

$$\frac{dI_y}{dL_y} = (1 - L_y)f''(L_y) < 0, \quad for \quad 0 < L_y < 1. \tag{1.24}$$

Thus, we obtain an important result:

Lemma 1.3 *FI in terms of final goods increases as the labor employment in the Y sector falls.*

This lemma tells us that changes in the labor allocation are closely related to economic growth and that we can analyze economic growth by examining the labor allocation to the Y sector.

The following task is to find the location of a production equilibrium on the production possibility frontier (PPF) and examine changes in the labor allocation among sectors. With a given value of N, we can construct the PPF among X, Y, and new know-how ($\dot{N}$) from equations (1.1), (1.3), (1.18) and (1.20). The marginal product of labor in the production of both good X and know-how is constant, while that in the production of good Y is diminishing. Thus, the PPF on both the X-Y

[12] If GNP is used as an index of economic growth, preference structure has to be specified to determine the amount of saving and hence interest revenue from the capital market. In order to highlight the contribution of technological progress to economic growth, we focus on FI.

plane and the Y-$\dot{N}$ plane is strictly concave to the origin, while the PPF on the X-$\dot{N}$ plane is linear. Figure 1 shows the PPF.

For the following arguments, it is convenient to use its projection on the X-Y plane, which is shown in Figure 2. Noting Lemma 1.2, suppose that in Figure 2, $X = OD_1 = (\beta r/\delta(1-\beta))N^{\frac{1}{\beta}-1}$, that is, point B is a production point where both equation (1.19) and $L_n = 0$ hold. Then, from Lemma 1.1, we see that 1) if $\beta = 1/2$, an interior equilibrium is located on BD_1, 2) if $1/2 < \beta < 1$, it is located on the locus such as BD_2, and 3) if $\delta/(r+2\delta) < \beta < 1/2$, it is located on the locus such as BD_3. Since there is no labor allocation to the R&D sector at point B, the labor corresponding to MA in terms of good Y equals the labor employed by the intermediate-good sector. As the labor employment in the Y sector falls, a production point moves towards point D_i ($i = 1,2,3$) on BD_i. At point E_1, for example, the labor corresponding to MA, AE, and EO in terms of good Y is, respectively, allocated to the intermediate good sector, the R&D sector, and the Y sector.[13] Suppose that the value of N increases and the new PPF is given by MH' in Figure 2. Then point B moves horizontally to B' because the labor allocation to the intermediate-good sector with $L_n = 0$ is independent of N and constant (recall Lemma 1.2). BD_i also shifts out proportionally (i.e., $BB'/AB = D_iD_i'/OD_i$).

In order to see both changes in the labor allocation to the Y sector and the location of a production equilibrium, one must consider the producer price, P, which is given by equation (1.19):

$$P = \frac{\beta N^{\frac{1}{\beta}-1}}{f'(L_y)}. \tag{1.25}$$

This is a key equation and leads to the following three lemmas that are useful for the following arguments. The first two lemmas are trivial from equation (1.25):

[13]Note that, at point E_2 (E_3), the labor corresponding to more (less) than MA in terms of good Y is allocated to the intermediate-good sector and the labor corresponding to EO is allocated to the Y sector.

Lemma 1.4 *With a given value of N, the producer price monotonically falls as the labor employment in the Y sector falls.*

Thus, on BD_i (MJ) in Figure 2, the producer price is the highest at B (M) and it falls and approaches zero as the production point moves towards D_i (J).

Lemma 1.5 *With a given labor employment in the Y sector, the producer price rises as the value of N increases.*

Thus, the producer prices at M and B increase as the value of N increases or as BD_i shifts to the right in Figure 2. That is, the producer price at B' is higher than the producer price at B and the producer price at M with the PPF, MH', is higher than the producer price at M with the PPF, MH.

Substituting a free trade equilibrium condition, $P^* = P$, into equation (1.25), we obtain the third lemma:

Lemma 1.6 *With a free trade equilibrium, the labor allocation to the Y sector falls and the labor allocation to the R&D sector rises as the value of N increases.*

This is because the intermediate-good and the R&D sectors can offer a higher wage as the value of N rises [see equation (1.19)]. Thus, labor leaves the Y sector. This implies that if there is positive R&D activity with a given technology level, there will be more R&D with a higher technology level.

Lemmas 1.3 and 1.6 lead to the following proposition;

Proposition 1.1 *Different technology levels (i.e., different values of N) result in different levels of FI. FI increases as the value of N increases.*

Next we derive the following lemma with respect to the location of the production equilibrium;

Lemma 1.7 *Suppose that the PPF on the X-Y plane is given by MH in Figure 2. Then, the production equilibrium is located on MBD_i (except at D_i).*

Noting that P^* is given, we confirm the following three possibilities with respect to the production of X and Y in equilibrium: 1) $P^* = P$ and positive production of both X and Y, 2) $P^* \geq P$ and no production of X, and 3) $P^* \leq P$ and no production of Y. It is easy to verify that the third case is not possible. Suppose that $Y = 0$. Then $L_y = 0$ and thus P is zero from equation (1.25). This contradicts $0 < P^* \leq P$. The second case with positive production of know-how is not possible, either. In the second case, since there is no production of X, there is no demand for intermediate goods and hence no R&D activity. Thus, complete specialization in good Y is the only possible equilibrium in the second case.

The first case will now be considered. As we have seen, an interior production equilibrium is located on BD_i (except at D_i) in Figure 2. Thus, we have only to determine if a point between M and H (except B) is consistent with the equilibrium conditions. By comparing such a point with point B, it can be shown that a production point between M and B is consistent with the equilibrium conditions, while a production point between B and H is not. We consider points K and I as examples. At point K (I), the output of good X and thus the output of each intermediate good, S, are less (greater) than that at point B. This implies from equation (1.15) that the profit, π, is smaller (greater) at K (I) than at B over time, and in turn from equation (1.10) that P_n is lower (higher) at K (I) than at B. Thus, noting that $W_s = W_n$ at B, we immediately see from equation (1.19) that $W_s > W_n$ ($W_s < W_n$) at K (I), which is consistent (inconsistent) with no R&D activity.

We are now ready to determine the location of the production equilibrium and to establish growth paths. The production equilibrium is located on MBD_i where the supply price equals the world price. Lemma 1.4 implies that the world price uniquely determines the production equilibrium point. In an equilibrium on MB, there is no labor allocation to the R&D sector and the technology level is constant over time. Thus, the labor allocation between the Y sector and the intermediate good sector is invariable and the sectoral composition of output and FI are constant over time. It should be noted, however, that the level of FI depends on the location of the equilibrium, and that even if both final goods are produced, there is no economic growth.

In an equilibrium between B and D_i, on the other hand, economic growth is generated by the increase in the value of N. Suppose that $\beta = 1/2$, $OD_1 = (\beta r/\delta(1-\beta))N(0)^{\frac{1}{\beta}-1}$, and $P^* = P$ at point E_1 in Figure 2. Then, E_1 is the equilibrium at $t = 0$. Since the labor corresponding to BE_1 in terms of good Y is allocated to the R&D sector, the value of N will be higher or BD_1 will shift to the right as time passes. Thus, Lemmas 1.3 and 1.6 confirm that the labor employment in the Y sector falls but the labor employment in the R&D sector and FI increases over time.

Since the labor employment in the Y sector decreases, the output of good Y decreases. Whether or not the output of good X increases in the process of economic growth depends on the value of β and the functional form $f(.)$. It is obvious from Lemma 1.1 and equation (1.18) that the output of good X increases if $1/2 \leq \beta < 1$. However, if $\delta/(r+2\delta) < \beta < 1/2$, the output of good X may decrease because the labor allocation to the intermediate-good sector decreases. Appendix C derives a necessary and sufficient condition under which the output of good X increases. The condition is

$$\frac{f''}{f'}L_s < \frac{2\beta - 1}{\beta}. \tag{1.26}$$

Since the left hand side is negative, we confirm that this condition always holds if $1/2 \leq \beta < 1$. If this condition holds, in Figure 2 changes in the sectoral composition of output, or growth path, induced by the increase in the value of N can be shown by a locus such as $E_1 Z$.

The location of the production equilibrium and the growth dynamics depend on the value of the world price, P^*, relative to the producer prices at B and M, P_B and P_M, at $t = 0$. In fact, this corresponds to the technology level at $t = 0$, $N(0)$, relative to the two "critical" technology levels, $\bar{N}$ and $\hat{N}$. $\bar{N}$ and $\hat{N}$ are, respectively, defined as the technology level such that the producer price at B equals the world price and the technology level such that producer price at M equals the world price, i.e.,

$$\bar{N} \equiv [\frac{P^* f'(1 - \frac{\beta r}{\delta(1-\beta)})}{\beta}]^{\frac{\beta}{1-\beta}},$$

$$\hat{N} \equiv [\frac{P^* f'(1)}{\beta}]^{\frac{\beta}{1-\beta}}.$$

Thus, noting Lemma 1.5, we see that 1) if $N(0) \leq \hat{N}$, then $P^* \geq P_M$ and hence the equilibrium is at M, 2) if $\hat{N} < N(0) < \bar{N}$, then $P_B < P^* < P_M$ and hence the equilibrium is located between M and B, 3) if $N(0) = \bar{N}$, then the equilibrium is at B, and 4) if $N(0) > \bar{N}$, then $P^* < P_B$ and hence the equilibrium is located between B and D_i.

The above analysis is summarized in the following two propositions:

Proposition 1.2 *If $N(0) \leq \hat{N}$, the economy completely specializes in good Y and FI is constant over time. If $\hat{N} < N(0) \leq \bar{N}$, the economy produces intermediate goods and final goods but FI is constant. If $N(0) > \bar{N}$, the economy engages in all productive activities and FI increases over time.*

Proposition 1.3 *If $N(0) \leq \bar{N}$, neither the labor allocation to each sector nor the sectoral composition of output changes over time. If $N(0) > \bar{N}$, the labor force is reallocated from the Y sector to the R&D and the intermediate-good sectors. The variety of intermediate goods increases, the output of good Y decreases, and the output of good X increases under equation (1.26).*

As we have seen above, FI increases if the value of N rises. When economic growth is studied, not only economic growth itself but also the growth rate often becomes a subject of discussion. We now examine changes in the growth rate of FI. We define $g \equiv \dot{I}_y / I_y$ and examine the sign of $\dot{g}$. First, note that

$$\dot{I}_y = \frac{dI_y}{dL_y}\frac{dL_y}{dt}. \tag{1.27}$$

From equation (1.25) under free trade, we obtain

$$\frac{dL_y}{dt} = \frac{1}{f''P^*}[\delta(1-\beta)L_n N^{\frac{1}{\beta}-1}] < 0. \tag{1.28}$$

Substituting equations (1.19), (1.24) and (1.28) into equation (1.27), we obtain

$$g = \frac{\dot{I}_y}{I_y} = \frac{\delta(1-\beta)}{\beta}\frac{(1-L_y)L_n f'}{(1-L_y)f'+f}. \tag{1.29}$$

Then, differentiating this equation with respect to L_y, we obtain:

$$\frac{dg}{dL_y} = \frac{\delta(1-\beta)}{\beta}\frac{[-L_n + (1-L_y)\frac{dL_n}{dL_y}]f'[(1-L_y)f'+f] + (1-L_y)L_n f'' f}{[(1-L_y)f'+f]^2} < 0.$$

Thus, $\dot{g} > 0$ always holds because $\dot{g} = (dg/dL_y)(dL_y/dt)$.

However, there is an upper bound of the growth rate. To see this, we rewrite equation (1.29) as follows:

$$g = [\frac{\delta(1-\beta)}{\beta}][\frac{(1-L_y)L_n}{(1-L_y)+f/f'}].$$

In the process of economic growth, L_y approaches zero. As L_y approaches zero, f and f', respectively, approach zero and infinite. Thus, in the second term of the right hand side, the denominator approaches 1, while the numerator approaches the limit value of L_n. Since L_n is bounded from above by 1, g is also bounded from above. If $\beta = 1/2$, for example, the limit value of L_n is $1 - r/\delta$ (recall Lemma 1.2) and hence the growth rate approaches $\delta - r$. Thus, the following proposition is obtained;

Proposition 1.4 *The growth rate of FI increases in the process of economic growth. However, there exists an upper bound of the growth rate.*

1.4 Policy Analysis under a Zero-Growth Equilibrium

An interpretation of an equilibrium on MB in Figure 2 is that the economy is trapped at a low-level (zero-growth) equilibrium because of a low initial technology level. Thus, a solution to avoid this low-level equilibrium is the accumulation of technology. However, no private sector has an incentive to increase the technology level. Thus, a policy is needed to start the accumulation of technology. Several policies such as taxes, subsidies, and tariffs are possible. In this section, we specifically examine a production tax on the Y sector and a wage subsidy to the R&D sector. With the aid of figures,[14] it is shown that these policies can be temporary to initiate economic growth.[15] The effects of an exogenous increase in the labor force is also examined.

1.4.1 A Production Tax on the Y Sector

We assume that the government imposes a production tax on the Y sector at time t. The imposition of the tax modifies equation (1.19) as follows:

$$W_y = \frac{P}{1+\tau} f' = W_s = \beta N^{\frac{1}{\beta}-1},$$

where τ is a tax rate. Noting that the value of N is not affected by the tax at time t and that $P = P^*$, we see that some labor must be released from the Y sector to other sector(s). If some labor is allocated to the R&D sector, economic growth begins. This is shown in Figure 3 as follows. Suppose that the economy is initially located at point K and $OD = (\beta r/\delta(1-\beta))N(0)^{\frac{1}{\beta}-1}$. First note that the imposition of the tax does not affect equation (1.21). Thus, the equilibrium must be located on MBD even if the tax is imposed. Suppose that the government picks a tax

[14]Although Figures 3, 4 and 5 are drawn with $\beta = 1/2$, the essential arguments do not change with $\beta \neq 1/2$.

[15]We assume that a tax is redistributed in a lump-sum manner and that a subsidy is financed by lump-sum taxation.

rate, τ, such that $P^*/(1+\tau) < P$ at B holds, for example, $P^*/(1+\tau) = P$ at E_t (recall Lemma 1.4). Then the tax shifts the equilibrium from point K to point E_t by reallocating some labor from the Y sector to the other two sectors.[16] Since the value of N increases, the output of good Y decreases and the output of good X increases. In Figure 3, changes in the sectoral composition of output are shown by E_tE_t' extended. Suppose that the PPF, MH', is drawn under the assumption that $N = \bar{N}$, that is, that $P^* = P$ at point B' (recall Lemma 1.5). Then, once the increase in the value of N shifts BD (MH) to the right of $B'D'$ (MH'), the economy will no longer need the tax. By removing the tax, the economy will be in a situation such that $\bar{N} < N$. Thus, technology accumulates even without the tax. If the government removes the tax immediately after point E_t' (where the growth path with the tax intersects $B'D'$) had been reached, then it will jump to the growth path, $B'Z'$.

1.4.2 A Wage Subsidy to the R&D Sector

We assume that the government introduces a wage subsidy to the R&D sector at time t. The subsidy modifies equations (1.19) and (1.21) as follows:

$$W_y = Pf' = W_s = \beta N^{\frac{1}{\beta}-1} = W_n(1+s) = \delta N P_n(1+s),$$

$$L_s = \frac{\beta r}{\delta(1-\beta)(1+s)} - \frac{1-2\beta}{1-\beta} L_n,$$

where s is a subsidy rate. These equations imply that the subsidy reallocates some labor from the intermediate-good sector to the R&D sector and hence economic growth commences. This is shown in Figure 4. Suppose that a free trade equilibrium is initially located between M and B, say, at K.[17]

[16] If $P^*/(1+\tau) \geq P$ at B, the equilibrium with the tax is located on KB and economic growth is not generated.

[17] At point M, the argument presented here does not hold because the world price is so high that there is no production of good X and no demand for know-how.

We know that $W_s > \delta N P_n = W_n$ at K. We assume that the government chooses a subsidy rate, s, such that $W_s = \delta N P_n(1+s) = W_n(1+s)$. There is no immediate impact of the subsidy on $N(t)$. From equation (1.25), this implies that the labor employment in the Y sector is the same as initially. Thus, the subsidy reallocates some labor from the intermediate-good sector to the R&D sector. Suppose that the subsidy decreases the output of good X by LL'. Then, the production equilibrium moves from K to E_s. That is, $K'E_s$ units of labor in terms of good Y are reallocated from the intermediate-good sector to the R&D sector and MA' units of labor in terms of good Y remain in the intermediate-good sector. Thus, changes in the sectoral composition of cutput under the subsidy is shown by E_sE_s' extended. However, once technology is accumulated up to the level of $\bar{N}$, the economy will no longer need the subsidy to generate economic growth. Suppose that MH' is drawn under the assumption that $N = \bar{N}$, that is, that $P^* = P$ at point B'. Then, N = $\bar{N}$ holds when the production of good X with the subsidy reaches OL''. Thus, if the government removes the subsidy immediately after point E_s' (where the growth path with the subsidy intersects $K''L''$) has been reached, then the economy will move to the growth path, $B'Z'$.

We thus obtain the following proposition:

Proposition 1.5 *If the economy is trapped at a low-level (zero-growth) equilibrium because of an insufficient technology level, a policy to initiate R&D can initiate economic growth. Such a policy could be temporary.*

It is worthwhile noting that although they can initiate growth, the production tax on the Y sector and the wage subsidy to the R&D sector, respectively, result in a different reallocation of labor at time t. The production tax reallocates some labor from the Y sector to the other two sectors, while the wage subsidy reallocates some labor from the intermediate-good sector to the R&D sector.

In our model, there exist two distortions: externalities in R&D and monopolistic competition in the intermediate-good market. In the R&D sector, producers fail to take account of knowledge creation which increases the productivity of R&D. From the social-optimum point of view, the R&D activity should be encouraged. Monopolistic competition also leads to less output of each intermediate good from the social-optimum point of view. Thus, the wage subsidy to the R&D sector enlarges the distortion from monopolistic competition, while the production tax on the Y sector can decrease both distortions. It should be emphasized, however, that the government needs permanent policies in order to attain the first-best equilibrium.

1.4.3 An Exogenous Increase in the Labor Force

Next we consider the effect of an exogenous increase in the labor force. Suppose that the labor force increases by ΔL at time t. Then both $\bar{N}$ and $\hat{N}$ are modified as follows:

$$\bar{N} \equiv [\frac{P^{*} f'(1 + \Delta L - \frac{\beta r}{\delta(1-\beta)})}{\beta}]^{\frac{\beta}{1-\beta}},$$

$$\hat{N} \equiv [\frac{P^{*} f'(1 + \Delta L)}{\beta}]^{\frac{\beta}{1-\beta}}.$$

It is obvious that both $\bar{N}$ and $\hat{N}$ decrease as ΔL increases. Thus a sufficiently large increase in the labor force initiates economic growth.

This can be shown in Figure 5. Suppose that the PPF on the X-Y plane shifts from MH to $M'H'$ in Figure 5.[18] First, note that even if the labor force increases, equation (1.21) does not change and hence Lemma 1.2 still holds. Thus, the production equilibrium must be located on $M'B'D$. However, it can be seen from equation (1.19) that the increase in the labor force has no immediate impact on the labor employment in the Y sector. Thus, if the economy is initially at point K, the increase in the labor force shifts the equilibrium from K to K'. At K', the labor

[18] An exogenous increase in the labor force shifts the PPF outwards and the shift is biased for good X.

corresponding to $B'K'$ in terms of good Y is newly allocated to the R&D sector and hence economic growth begins.

Since there is no change in the labor allocation to the Y sector at time t, neither the wage rate nor the rental rate changes at time t. Thus, if the labor force is proportional to population, per capita FI falls at time t. However, if the increase in the labor force is once and for all, economic growth will eventually result in an increase in per capita FI, beyond its initial level. If, on the other hand, the increase in the labor force is continuous (say, continuous population growth), the increase in the labor force has two opposite affects on economic growth: first, it decreases per capita FI and second, it accelerates the accumulation of technology. Thus, even if technology is accumulating, per capita FI may decrease.

The above analysis leads to:

Proposition 1.6 *An exogenous increase in the labor force under a zero-growth equilibrium may initiate economic growth. At the time of the increase, both the wage rate and the rental rate do not change and per capita FI decreases.*

1.5 Concluding Remarks

The patterns of economic growth for a multi-sector, SOE have been analyzed. Key points are that augmentation of the technology level through R&D generates economic growth, and that changes in the technology level are endogenously determined because the labor allocation to the R&D sector is endogenous.

Whether or not the technology level rises under free trade depends on its initial level. A sufficiently high initial level of technology leads to a self-made process of technology accumulation and thus continuous economic growth. In this case, not only the economy grows but also the growth rate increases over time. Dynamic IRS play a important role in this result. An insufficient initial level of technology, on the other hand, cannot lead to any accumulation under free trade and thus the economy is trapped at a low-level (zero-growth) equilibrium over time. It should be emphasized that even if both final goods are produced, zero growth is possible, and that different technology levels lead to different levels of FI. These results capture the observed diversity across countries in both levels and rates of growth of per capita income.

Two critical technology levels have been defined to determine whether or not an initial technology level is sufficient. It should be noted that critical technology levels depend on the world price, P^*, and the world instantaneous interest rate, r. It is easy to see that both critical technology levels rise as the world price rises and that the critical technology level, $\bar{N}$, rises as the world instantaneous interest rate rises. Thus, any exogenous changes in those parameters will affect economic growth.

If the initial technology level is not sufficient to generate economic growth, the government can initiate economic growth by imposing a temporary policy to create technology accumulation. Although there exist dynamic IRS associated with the technology accumulation, they are purely external. Thus, no private agent has an incentive to increase the technology level in a zero-growth equilibrium. The economy without a sufficient initial level of technology cannot enjoy dynamic externalities. Therefore, government intervention to capture dynamic externalities may be justified. We have considered two temporary policies: a production tax on the Y sector and a wage subsidy to the R&D sector. It has also been shown that an exogenous increase in the labor endowment can solve the zero-growth problem.

Even if the technology is accumulated without any intervention, monopolistic competition results in less output of each intermediate good from the social-optimum point of view. Externalities in R&D also lead to less R&D activity from the social-optimum point of view. Thus, permanent intervention by the government can also be justified. Such policies have not been analyzed in this essay.

Changes in the labor allocation among sectors are closely related to the evolution of the sectoral composition of output and economic growth. In the process of economic growth, it has been shown that some labor necessarily shifts from the Y sector to the R&D sector, and that changes in the labor allocation to the intermediate-good sector crucially depend on the value of β. Since the Y sector releases labor at increasing marginal costs, FI increases in our model.

As Grossman and Helpman (1989b) show, it is possible to incorporate the diffusion of knowledge created in R&D from the rest of the world (ROW). Knowledge can diffuse through publications, conferences, personal contact etc. In the presence of knowledge diffusion from the ROW, economic growth can be magnified by increasing the productivity in R&D. Even if the economy is initially in a zero-growth equilibrium, knowledge diffusion can initiate economic growth in the future.

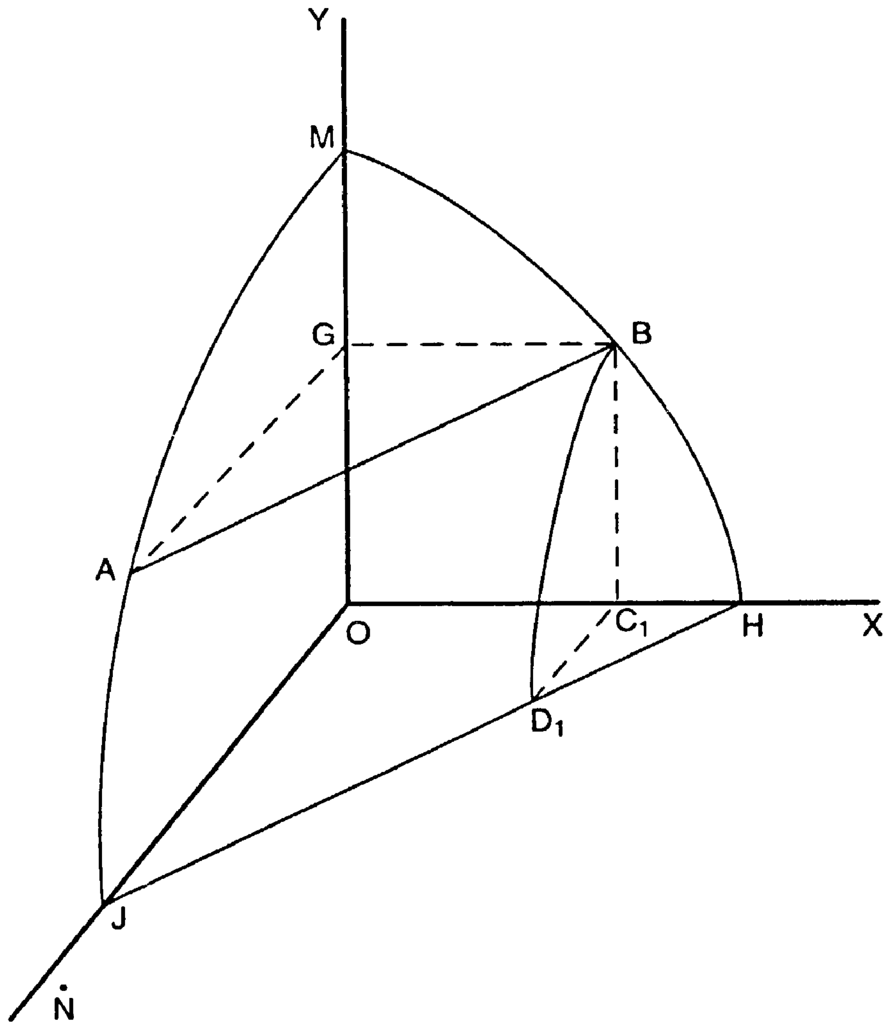

Fig. 1

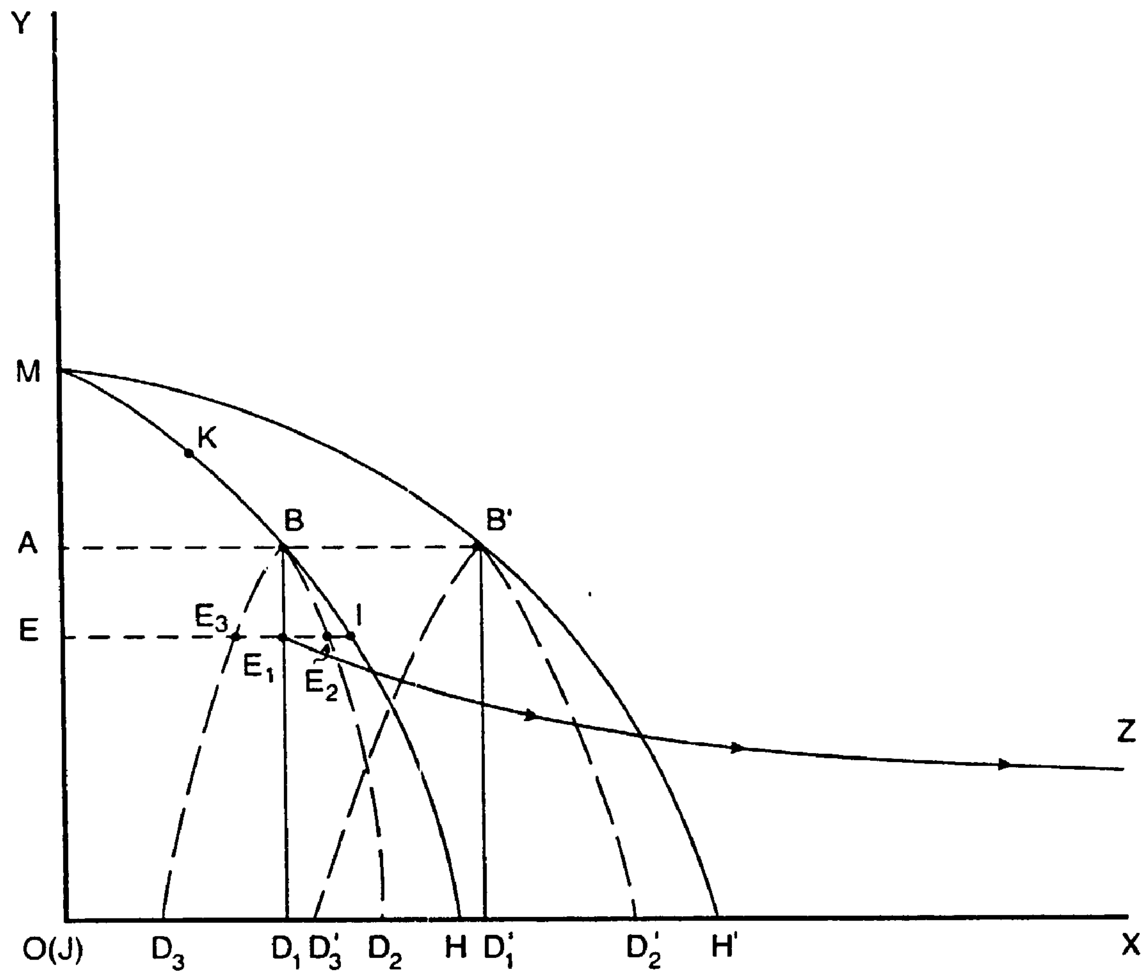

Fig. 2

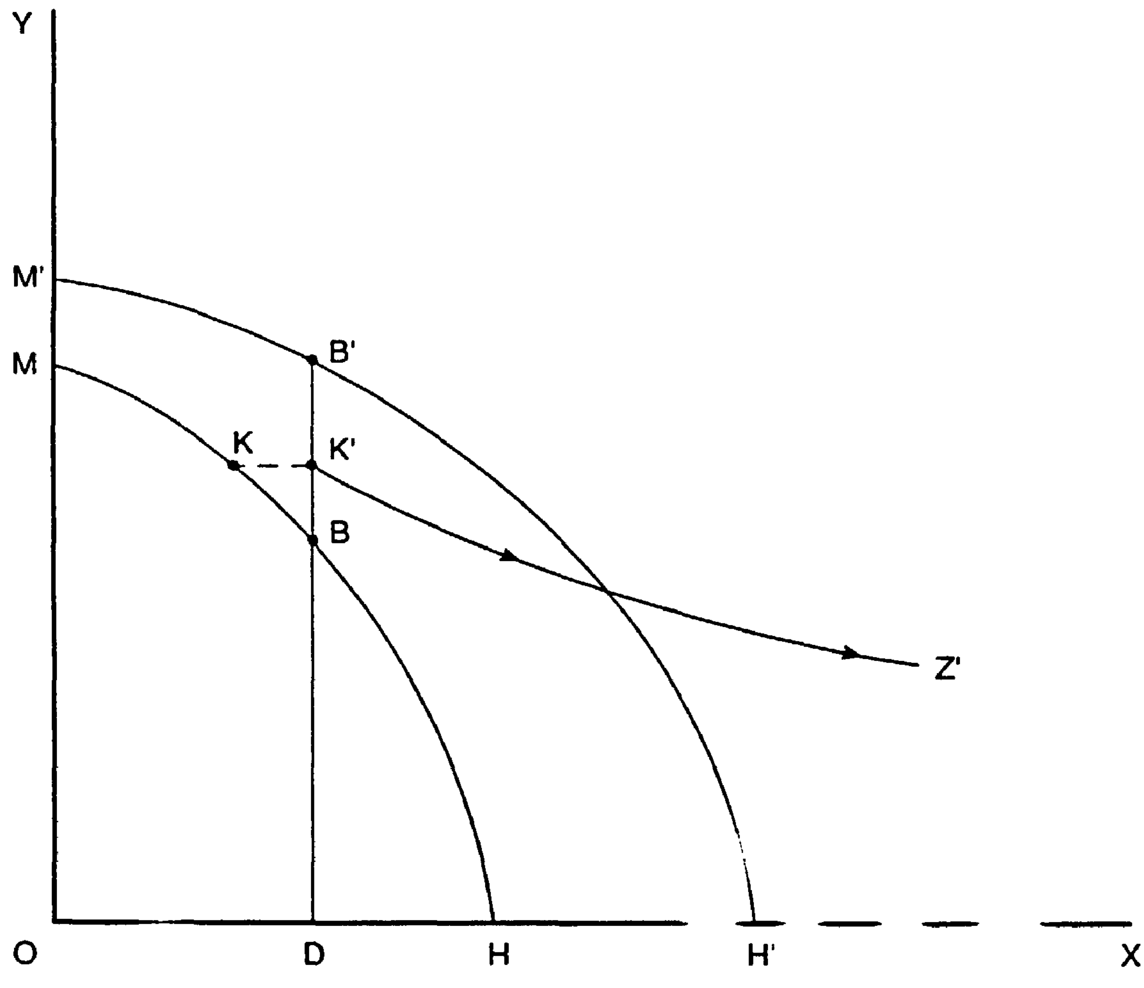

Fig. 3

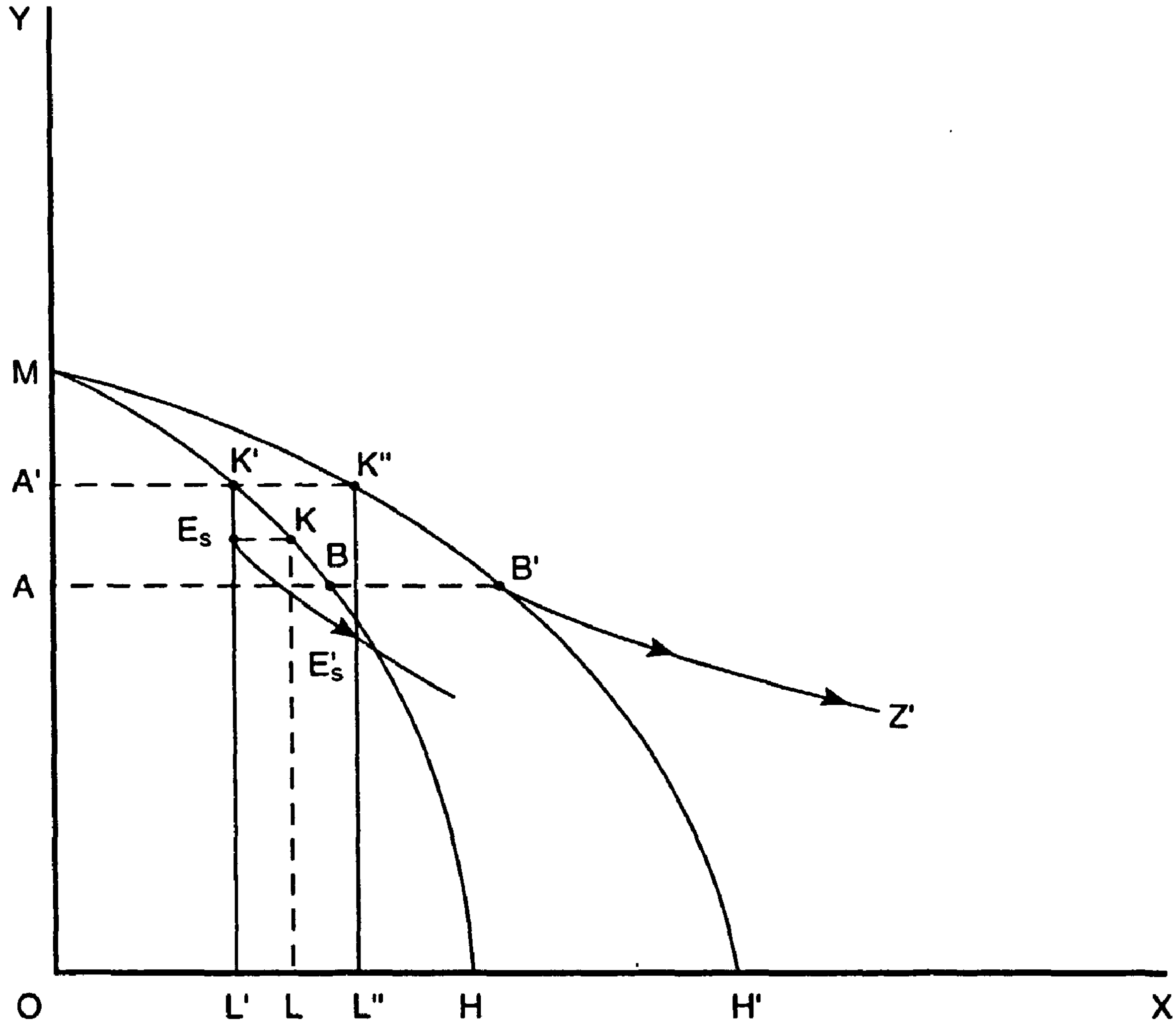

Fig. 4

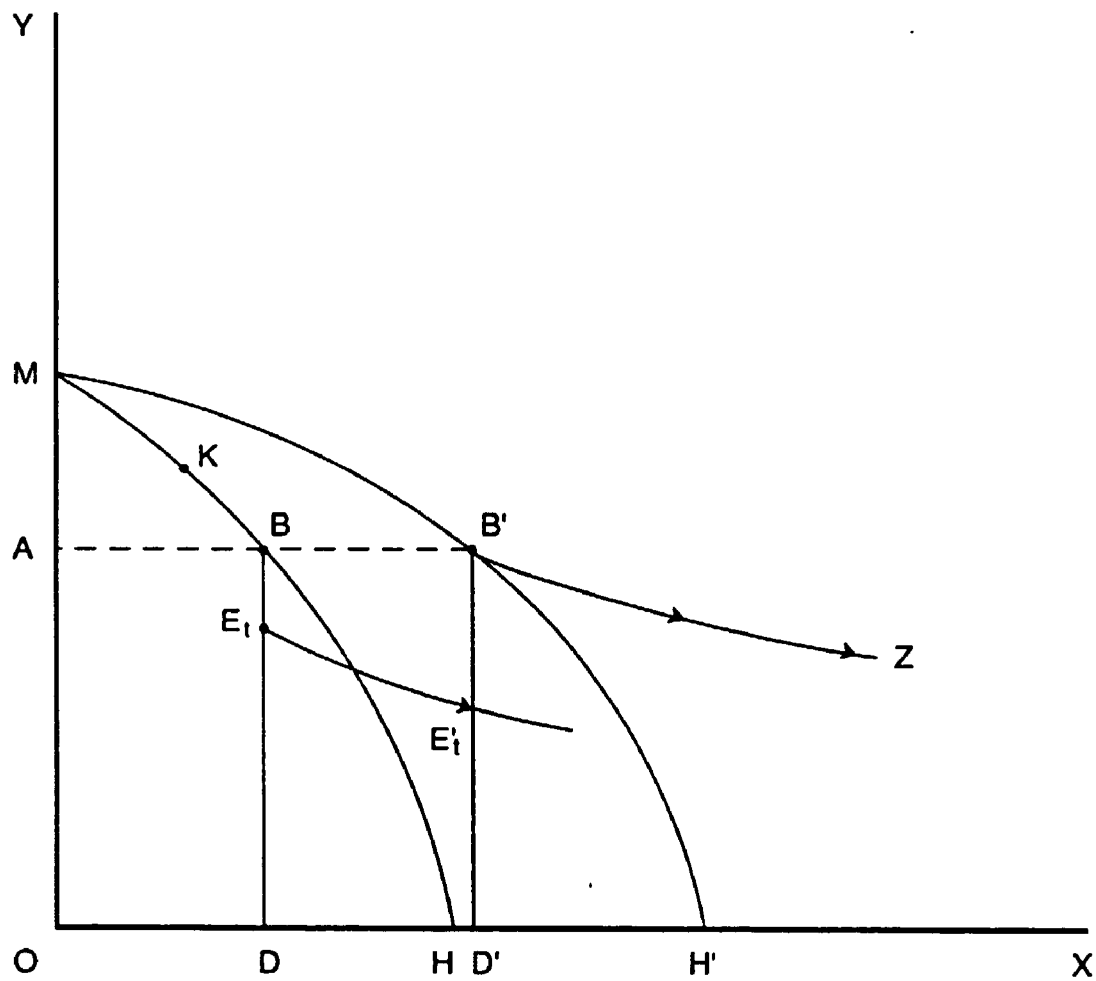

Fig. 5

Appendix 1.A

In this appendix, we derive equation (1.21) from equations (1.1), (1.11), (1.16), (1.17) and (1.19). From equation (1.19), we obtain

$$\frac{\dot{W}}{W} = \frac{1-\beta}{\beta}\frac{\dot{N}}{N}.$$

Substituting this equation into equation (1.11) and using equation (1.1), we obtain

$$\pi = \frac{W}{\delta N}(r - \frac{1-2\beta}{\beta}\frac{\dot{N}}{N}) = \frac{W}{\delta N}[r - \frac{(1-2\beta)\delta}{\beta}L_n].$$

Substituting this equation into equation (1.16), we obtain

$$S = \frac{\beta}{\delta N(1-\beta)}[r - \frac{(1-2\beta)\delta}{\beta}L_n].$$

Substituting this equation into equation (1.17), we obtain equation (1.21).

Appendix 1.B

This appendix shows that if $0 < \beta < \delta/(r + 2\delta)$, L_s becomes zero at some point in time in the process of economic growth. We substitute $L_s = 0$ into equation (1.21) to obtain

$$L_n = \frac{\beta r}{\delta(1-2\beta)}.$$

If L_n is less than the labor endowment (=1) with $L_s = 0$, $L_s = 0$ holds at some point in time in the process of economic growth. Thus, we obtain the result.

Appendix 1.C

This appendix derives a necessary and sufficient condition under which the output of good X increases in the process of economic growth. From equation (1.18), we know that the output of good X increases in the process of economic growth if and only if

$$\frac{d\ln X}{dt} = \frac{1-\beta}{\beta}\frac{\dot{N}}{N} + \frac{\dot{L}_s}{L_s} > 0. \tag{1.30}$$

From equations (1.20) and (1.21), we obtain

$$L_s = \frac{r}{\delta} + \frac{2\beta - 1}{\beta}(1 - L_y).$$

Thus,

$$\dot{L}_s = \frac{1-2\beta}{\beta}\dot{L}_y.$$

Substituting equation (1.29) into this equation and noting equations (1.1) and (1.19), we obtain

$$\dot{L}_s = \frac{(1-2\beta)(1-\beta)f'\dot{N}}{\beta^2 f'' N}.$$

Substituting this equation into equation (1.30), we obtain

$$\frac{d\ln X}{dt} = \frac{1-\beta}{\beta}\frac{\dot{N}}{N}\left(1 + \frac{(1-2\beta)f'}{\beta f'' L_s}\right) > 0.$$

This condition is equivalent to

$$\frac{f''}{f'}L_s < \frac{2\beta - 1}{\beta}.$$

Chapter 2

Technology Policies, Technological Leadership of Multinational Enterprise, and the R&D by Domestic Firms

2.1 Motivation and Introduction

It is well known that technological change is important to economic growth. Recently, the importance of R&D to economic growth has received attention in the analytical literature. Most of this work, for an example Grossman and Helpman (1989), studies the determinants of domestic R&D activities and their contribution to economic growth. However, it is questionable whether these theoretical models developed for the case of industrialized countries are applicable to LDCs. Hence, it is important to study the determinants of technological change in LDCs and hopefully we could get some policy implications which are more relevant to them.

In LDCs, technology transfer from abroad is likely to be an important source of technological change, in addition to R&D by domestic firms. There are two major forms of international technology transfer. One is foreign direct investment by multinational firms [1]. Recently, licensing has become another important form

[1]The effects of the operation of multinational firm on LDCs have been widely documented in the literature of economic development. A good reference is Meier (1984).

of technology transfer [2]. However, there are few analytical works which study the relation among direct investment by multinational firms, licensing of technology, and technological change in LDCs. The present study attempts to clarify a number of issues that arise in this area.

In comparison with firms in LDCs, a multinational firm with access to advanced technology, has a competitive advantange [3]. This competitive advantage may affect the R&D intensity of the domestic competitors and hence the industrial organization in many sectors in LDCs . In the presence of technological superiority, a multinational firm is likely to become the dominant firm in the product market in the short run. However, its effects on the long run organization of an industry are uncertain. One can distinguish two opposing forces acting on it.

First, there may be a spillover effect from the multinational firm which may improve the domestic competitors' R&D capability or direct production productivity [4]. This effect tends to increase the R&D intensity of domestic competitors and then decreases the competitive advantage of the multinational firm in the long run [5].

Second, the technological superiority of the multinational firm may imply smaller

[2]As mentioned by Marton (1986), " ··· The competitive position of individual MNCs can be maintained only if they retain their technological advantage, either through company-internal research or through licensing, cross-licensing, and various forms of technology-pooling arrangements. The scope and magnitude of such arrangements have increased considerately in recent years, with the rapid expansion of trade in technology. In the case of U.S. companies alone, income from technology fees and royalties increased from $ 2,787 million in 1971 to $ 6,275 million in 1983. Of this, $1,594 million and $ 4,056 million respectively, comprised receipts from developed market economies, while income from developing countries amounted to $ 537 million in 1971 and $ 1,278 million in 1983. ···".

[3]As mentioned by Frank (1980), "··· To the extent that the multinationals enter fields in which local firms already exist or where the near-term potential for local enterprise is significant, the fear exists that incipient indigenous entrepreneurship will be stifled. To the developing countries, this threat is enhanced by the tremendous technological and financial advantages of the multinationals as well as by their advertising, promotion, and product-differentiating practices. ···". By using Canadian data, Gorecki (1975) and Shapiro (1983) support the hypothesis that subsidiaries of MNCs possess advantages relative to domestic firms in overcoming barriers to entry in the host market.

[4]The presence of spillovers is widely documented in the literature. Blomstrom and Persson (1983), Chen (1983), and Mansfield and Romeo (1980) provide evidence of the existence of spillovers from multinational firms.

[5]Das (1987) studies the effect of these spillovers on the dynamic production plans of the multinational firm.

expected future earnings from doing R&D. This effect discourages the R&D activities of the domestic competitors [6]. Hence, this second effect tends to increase the multinational firm's competitive advantage in the long run.

In the presence of these effects, MNE (multinational enterprise) can adjust the technology it transfers to the LDC so as to influence the domestic firm's R&D intensity. This paper studies how the second effect noted above affects the technology level of the multinational firm and also the R&D intensity of domestic competitors. On the other hand, we also discuss how certain kinds of government policies affect the technology level of the multinational firm and the R&D intensity of the domestic competitors. In this way, this essay tries to improve our understanding of the effects of technology policies in LDCs in the presence of foreign direct investment (FDI).

Instead of doing R&D, some domestic firms may seek access to better technology through licensing agreements. Domestic licensees may then acquire the same kind of technological superiority as the multinational firm in an FDI regime. This, in turn, has a similar effect on the R&D intensity of other domestic competitors without the licensed technology. It has been shown by Gallini (1984) that licensing can be used as a tool in entry deterrence, which can affect rivals' R&D intensity [7]. In this paper, we are going to discuss how licensing of some firms influence the R&D intensity of non-licensed domestic competitors. The effects of government regulations on the amount of licensing payments will also be discussed.

We are considering a foreign firm (henceforth referred to as the MNE) having technological leadership, which chooses either to set up a production facility in a host country, or to license its technology to domestic firms in this country. In sec-

[6] Globerman and Meredith (1984) suggest that high levels of foreign ownership have a depressing influence on industry - R&D expenditures in Canada. On the other hand, Veugelers and Vanden Houte (1990) also find a similar evidence by using Belgian data.

[7] In her paper, she considers a simple case in which there is one incumbent and one potential entrant. She shows that " ⋯ a license contract may lead to termination of research even when the undiscovered technology are sufficiently profitable that both firms could be accomodated in R&D activity. ⋯ ". We are going to consider a licensing equilibrium in which potential entrant may do R&D even if the foreign firm licenses its technology to some domestic firms.

tion 2.2, we describe a simple model of an FDI regime, in which a multinational firm establishes an LDC subsidiary having a technological advantage over domestic firms. This advantage provides monopoly power to this multinational firm (through its subsidiary) in the LDC market . However, we assume there is a domestic potential entrant which can carry out R&D activities in order to compete with the multinational firm. The R&D process is described by a Poisson process such that the arrival date of a successful innovation is a random variable [8]. We assume the multinational firm is a leader of the game so that it would consider the effect of its technology level on the R&D activities by the domestic potential entrant. We provide conditions under which an equilibrium of this leader-follower game exists. Furthermore, we perform some comparative statics experiments in order to understand the properties of this equilibrium .

In section 2.3, we consider the possibility of licensing. We first consider the simple case in which there is only one licensee. Second, we allow the presence of more than one licensee for the same technology. It can be shown that there are two possibilities in a licensing equilibrium. A potential domestic entrant will do R&D in one kind of licensing equilibrium, but not in the other. This result shows an example of the possible entry deterrence purpose of licensing. We further discuss the welfare implications of the FDI regime and the licensing regime, using a measure based on aggregate consumer surplus and the profit if domestic firms in the relevant market.

In section 2.4, we study the effects of government policies that influence technology transfers. First, we consider two policies in the FDI regime. One is a subsidy on the R&D activities by the domestic firm; we also study the effect of a subsidy on the technology transfer by the multinational firm . Second, we consider the effect of an upper bound, imposed by the host government on the licensing payments , from

[8] Mention should be given to the seminal work by Reinganum (1983). In her model, there is one incumbent doing preemptive research and another potential entrant doing research in order to enter the market. She assumes a similar random process and a Nash relation (instead of leader-follower relation as in our model) between the incumbent and the potential entrant.

the domestic licensees to the MNE. Welfare implications of these policies will also be discussed. Section 2.5 finally provides concluding remarks.

2.2 Foreign Direct Investment and R&D by Domestic Firms

In this section, we first consider the case in which the foreign firm chooses the strategy of establishing a subsidiary with a production facility in the LDC. We call this the FDI regime. Before the entry of the multinational firm to the domestic market, there is one domestic firm supplying a homogenous good which is produced under a constant marginal cost of production , $\bar{C}^D$ (in this model, the level of technology is represented by the magnitude of the marginal cost of production).

2.2.1 MNE's technology level

We assume that there is one multinational firm which can choose its technology of production from a set of feasible technology, $C^M \in [\underline{C}^M, \bar{C}^M]$. There is a fixed cost of technology transfer, composed of elements such as training cost and adoption cost [9]. We assume that it involves a higher fixed cost if the multinational firm wants to adopt a more advanced technology (i.e. a production technology with a lower marginal cost of production) . If the multinational firm spends X as the cost of technology transfer, the corresponding technology level is $C^M(X)$. We assume $C^M(\cdot)$ has the following properties:

(C.1): $C^{M\prime} = \dfrac{dC^M(X)}{dX} < 0$,

[9] Mansfield et.al. (1982) provide a good description for the cost of technology transfer "as the costs of transmitting and absorbing all of the relevant unembodied knowledge. They include the cost of pre-engineering technological exchanges during which the basic characteristics of the technology are revealed to the transferee. They include the engineering costs associated with transferring the process design and the associated process engineering in the case of process innovations, or the associated product design and production engineering in the case of product innovations. They also include the R&D costs involved in adopting and modifying technology. And they include the pre-start-up training costs and the learning and debugging costs incurred during the start-up phase, and before the plant achieves the design preformance specification." According to their study of a sample of projects, transfer costs averaged about 20 percent of total project cost.

(C.2): $C^{M''} = \dfrac{d^2C^M(X)}{dX^2} > 0$,

(C.3): $\lim_{X\to 0} C^{M'}(X) = \infty$,

(C.4) $\lim_{X\to \infty} C^{M'}(X) = 0$,

(C.5): $\lim_{X\to 0} C^{M}(X) = \bar{C}^M$,

(C.6): $\lim_{X\to \infty} C^{M}(X) = \underline{C}^M$.

C.1 and C.2 imply that the cost function is monotonic and convex. C.3 and C.4 are used later to support an interior equilibrium. C.5 and C.6 describe the lower and upper bounds of the technologically feasible set.

2.2.2 Cournot equilibrium in the product market

We now discuss the properties of the subgame perfect equilibrium before and after any technological innovation. We assume that t = 0 when the MNE starts its production in the LDC. The demand side is represented by a downward sloping demand function, $D(Q)$ such that

$(D.1): D' < 0.$

We assume that the industry is sufficiently small in relation to the economy as a whole, so that we can disregard any effect on the demand function of changes resulting from technological progress in the industry. (However, there would be no qualitative changes in the main results of the paper if we did allow for such effects, letting D_B (D_A) denotes the demand function before (after) the occurence of a successful innovation; the profit functions used in the analysis would then be computed on the basis of these two different demand functions. But in order to do this, we would have to impose a number of restrictions on the preference structure of consumers, for example, by specifying the direction and magnitude of the income elasticity of demand for this good relative to other goods.)

Competition in the final good market is characterized by the Cournot-Nash assumption. We simply assume a Cournot-Nash equilibrium always exists in the final good market. (Sufficient conditions for existence are widely documented in the literature.) Hence, the profit of firm i is a function of the set of marginal costs of all producers in the final good market. We assume this profit function is twice continuously differentiable with respect to all elements in the set of marginal cost. In the case of two firms, one can easily show the following property :

$$\pi^i = \pi^i(C^i; C^j); \quad \pi^i_{C^i} < 0; \quad \pi^i_{C^j} > 0$$

where

C^j represents the marginal cost of the other firm in the market, and

π^i represents the instantaneous profit function of firm i.

We use M to denote the multinational firm. For the sake of simplicity, we assume that when the MNE enters the LDC industry, the technology transfer is drastic, [10] that is the technology level of the multinational firm is so superior that no domestic firm can compete with it:

$$\pi^D(\bar{C}^D; \bar{C}^M) \leq 0.$$

Hence, there will be only one firm, the multinational firm, after its entry [11]. However, we assume that there are research opportunities through which a domestic firm can improve its competitive position by spending resources on R&D. Suppose it is profitable for the potential domestic entrant to carry out R&D [12]. Then, there are two regimes. One is the monopoly regime in which there is only the multinational

[10] We borrow this term from the literature on R&D competition.

[11] This is a simplifying assumption. In the absence of this assumption, there will be two regimes in which there are two suppliers in the product market. In the first regime, there will be one multinational firm having a superior technology with one technologically-inferior domestic firms. After the occurrence of a successful innovation, the technology level of the inferior firm is increased. However, one can show that most of the analytic results would not change in such a version of the model.

[12] We shall later discuss some conditions under which it is not profitable for the domestic entrant to do R&D.

firm in the market. The other is the duopoly regime in which there is a domestic firm competing with the multinational firm, following a successful innovation. We are going to discuss the properties of the instantaneous profit functions, which are useful in further analysis, in these regimes.

Before the occurrence of a successful innovation,the MNE is a monopoly. The instantaneous monopoly profit is represented by:

$$R(C^M) = [D(q^M) - C^M]q^M$$

From the envelope theorem and the assumption D.2 below, that marginal revenue is decreasing with respect to the total output,

$$(D.2) : 2D' + D''q^M < 0,$$

we can derive the following two properties:

$$R_{C^M} = -q^M < 0$$

and

$$R_{C^MC^M} = -\frac{dq^M}{dC^M} > 0$$

Hence, the monopoly profit function, $R(C^M)$, is convex in C^M. This implies a possibility that a reduction in the marginal cost of production, by spending more resources on technology transfer, might increase the profit in the monopoly regime at an increasing rate. This possibility generates a problem with respect to the existence of an interior solution to the multinational firm's decision on the technology level. We therefore need to impose an upper bound on the degree of convexity of the monopoly profit function in order to support the existence of an interior solution . If we do not restrict the second order derivative of the profit function, the MNE's best strategy may be a corner solution [13] . Accordingly, we impose the following

[13] I.e., the MNE may choose the most advanced technology level ($\underline{C}^M$) at the maximum monopoly profit.

assumption, which imposes an upper bound on the rate of increase in profit in the monopoly regime from an additional improvement in technology, in the following analysis:

$$(D.3) : \psi/\phi > -\nu$$

where $\phi = \dfrac{C'(X)X}{C(X)}$, $\psi = \dfrac{C''(X)X}{C'(X)}$, and $\nu = \dfrac{R_{C^M C^M} C^M}{R_{C^M}}$.

Assumption D.3 implies that the degree of convexity of the monopoly profit function is less than the ratio of the elasticities of $C(\cdot)$ and its first order derivative with respect to X.

After the occurrence of a successful innovationby the domestic firm, the multinational firm and the domestic entrant, which is assumed to hold a patent covering the innovation, form a duopoly in the final good market. The instantaneous profit functions of the multinational firm ($\pi^M(C^M, C^D)$) and the domestic firm ($\pi^D(C^D, C^M)$) can be represented as:

$$\pi^M(C^M, C^D) = [D(q^M + q^D) - C^M]q^M,$$

$$\pi^D(C^D, C^M) = [D(q^M + q^D) - C^D]q^D.$$

Assuming that the Gale - Nikado condition (described by D.4 below) is satisfied, the equilibrium (q^{M*}, q^{D*}) would be unique and stable.

$$(D.4) : \pi^M_{q^M q^M} \pi^D_{q^D q^D} - \pi^M_{q^M q^D} \pi^D_{q^M q^D} > 0.$$

From D.4, we can derive the following: for $(i, j) = (M, D)$ or (D, M)

$$\frac{dq^{i*}}{dC^i} < 0, \quad \frac{dq^{i*}}{dC^j} > 0$$

and

$$\frac{dQ^*}{dC^M}, \quad \frac{dQ^*}{dC^D} < 0$$

where $Q^* = q^{M*} + q^{D*}$. We can also derive the following:

$$\frac{d\pi^i}{dC^i} = D'\frac{dq^{j*}}{dC^i} - q^{i*} < 0,$$

$$\frac{d\pi^i}{dC^j} = D'\frac{dq^{j*}}{dC^j} > 0.$$

These results imply that an increase in the technology level of the multinational firm not only increases the profit (gross of the cost of technology transfer) in the monopoly regime, it also increases its profit in the duopoly regime. However, a higher technology level adopted by the multinational firm decreases the profit of the domestic firm in the duopoly regime, which is shown later to lead to a lower R&D intensity by the domestic firm and hence to a longer duration of the monopoly regime. We shall impose the following restriction in order to guarantee the existence of an interior equilibrium:

- $(D.5): \pi^M_{CM} < R^M_{CM}$

Assumption D.5 implies that an increase in the technology level of the MNE increases the instantaneous profit in the duopoly regime by more than that in the monopoly regime. This assumption eliminates the possibility that the MNE may adopt the most advanced technology (upper corner solution) in order to get the maximum duration of the monopoly regime.

We cannot determine the signs of the second order derivatives with respect to C^i and C^j from our basic assumptions on the demand function [14]. Hence, π^i for $i = M, D$ may be concave or convex in C^i or C^j under our basic assumptions on the demand curve. For the same reason as discussed earlier, we need to impose

[14]One can show the following:

$$\frac{d^2\pi^i}{dC^{j2}} = D'\frac{d^2q^{j*}}{dC^{j2}} + D''\frac{dq^{j*}}{dC^j}\frac{dQ^*}{dC^j} \gtrless 0,$$

$$\frac{d^2\pi^i}{dC^{i2}} = D'\frac{d^2q^{j*}}{dC^{i2}} - \frac{dq^{i*}}{dC^i} + D''\frac{dq^{j*}}{dC^i}\frac{dQ^*}{dC^i} \gtrless 0.$$

an upper bound on the degree of convexity of MNE's duopoly profit function with respect to X. On the other hand, the second order derivative of π^D with respect to C^M may affect the existence of an interior equilibrium since the sign and the magnitude of this derivative may affect the magnitude of the strategic interdependence between the domestic firm and the MNE. If the sign of this derivative is positive and its magnitude is large, MNE may again want to choose the upper bound of its technology level in order to get the maximum duration of monopoly. Hence, we are also going to restrict the degree of convexity of the domestic firm's profit function with respect to the MNE's technology level in order to support the existence of an interior equilibrium, by assumption D.6:

$$(D.6): \psi/\phi > Max[-\xi^D, -\xi^M]$$

where $\xi^D = \dfrac{\pi^D_{C^M C^M} C^M}{\pi^D_{C^M}}$ and $\xi^M = \dfrac{\pi^M_{C^M C^M} C^M}{\pi^M_{C^M}}$.

2.2.3 The game I: Potential domestic entrant's R&D intensity

Assuming the game starts at $t = 0$. At this instant, the game is played in two stages. First, the multinational firm decides its technology level. We assume the multinational firm is a leader of the game so that it also considers the effect on the potential domestic entrant's R&D of its choice of technology level [15] . After the anouncement of the technology level of the multinational firm, the potential entrant decides on its intensity of R&D. Following the literature on patent races [16] , we assume that the R&D is a Poisson process and the patent has an infinitely long life. In this game, we describe the outcome of the innovation as an attainable marginal production cost, C^D, such that:

(I.1): $\bar{C}^M \leq C^D < \bar{C}^D$,

[15]This assumption captures the fact that the decision by a multinational firm may consider its strategic effect on its domestic competitors. This assumption is widely used in the literature on foreign investment.

[16]Dasgupta and Stiglitz (1980), Lee and Wilde (1980), Loury (1979), and Reinganum (1983)

(I.2): $\pi^D(C^D; \underline{C}^M) > 0$.

I.1 and I.2 imply that the technology level of the domestic entrant after a successful innovation is lower than that of the multinational firm [17] but it is high enough to enter the market.

The potential domestic entrant can choose the parameter of the Poisson process, $\lambda\gamma$, through choosing a flow of R&D expenditure $F(\gamma)$ which has the following properties:

(F.1): $F' = \dfrac{dF(\gamma)}{d\gamma} > 0$,

(F.2): $F'' = \dfrac{d^2F(\gamma)}{d\gamma^2} > 0$,

(F.3): $F(0) = 0$,

(F.4): $F''' < 0$ and $F'''\gamma / F'' < -3$.

F.1 and F.2 imply that the domestic entrant has to pay a higher cost if it wants a higher probability of the discovery of a successful innovation at an early date. F.3 implies that if there is no flow of R&D expenditure, there is no probability of an innovation. F.4 is needed to support the existence of an interior equilibrium; we shall provide a discussion of its implication in the later analysis.

If this firm spends $\{F(\gamma)dt\}$ between time t and t + dt, its probability of making a discovery during this interval is $\lambda\gamma dt$. Suppose R&D starts at t = 0. Then the probability that by time t there is no discovery is

$$\exp^{-\lambda\gamma t}$$

If an innovation occurs at time t, the entrant earns the flow π^D forever. Thus, conditional on the absence of an innovation before t, with probability $\lambda\gamma dt$, the entrant can earn

$$\exp^{-rt}\Pi^D(C^D, C^M) = \exp^{-rt}\pi^D(C^D; C^M)/r$$

[17] I.1 eliminates the possibility that the domestic firm will be technologically-superior to the multinational firm after a successful innovation.

where r is the instantaneous interest rate.

We also assume that there is a fixed cost, H, in the R&D process. Given the technology level of the multinational firm, the expected profit of the domestic potential entrant is then represented by

$$\begin{aligned} V^D(\gamma; C^M) &= \int_0^\infty \exp^{-(r+\lambda\gamma)t}[\lambda\gamma\Pi^D(C^D, C^M) - F(\gamma)]dt - H \\ &= \frac{\lambda\gamma\Pi^D(C^D, C^M) - F(\gamma)}{r + \lambda\gamma} - H \end{aligned}$$

We shall now discuss the optimal decision of this potential entrant for a given technology level of the multinational firm. Taking the derivative of the expected profit of the domestic entrant with respect to γ,

$$\begin{aligned} Z(\gamma; C^M) = \frac{dV^D}{d\gamma} &= \frac{\lambda\Pi^D - F'(\gamma)}{r + \lambda\gamma} - \frac{\lambda(V^D + H)}{r + \lambda\gamma} \\ &= \frac{\lambda(\pi^D + F)}{(r + \lambda\gamma)^2} - \frac{F'}{(r + \lambda\gamma)} \end{aligned} \tag{2.1}$$

The first order condition implies $Z(\gamma^*; C^M) = 0$ [18]. From equation (2.1), we can interpret the benefit and cost of increasing the R&D intensity. First, an increase in the R&D intensity increases the probability of the arrival of a successful innovation at each instant. This effect increases the expected profit since the expected date of the arrival of a successful innovation is coming earlier, so that the domestic potential entrant can expect to enter the market earlier. Moreover, an earlier arrival of a successful innovation implies that the domestic firm can save future expenditure on R&D. These two effects are also represented by the first term in equation (2.1). However, an increase in the R&D intensity also increases the R&D expenditure at each instant. This represents the marginal cost, which is the second term in equation (2.1).

[18] Assuming γ^* exists, one can check that the second order condition is satisfied:

$$\left.\frac{d^2V^D}{d\gamma^2}\right|_{\gamma=\gamma^*} = -F''(\gamma^*)/(r + \lambda\gamma^*) < 0$$

From equation (2.1), we have our first proposition:

Proposition 2.1 *If $\lambda\pi^D(C^D,\bar{C}^M) < r(F'(0)+\lambda H)$, there is no R&D by the domestic potential entrant and hence the duration of the monopoly regime will be infinite.*

Proposition 2.1 shows the condition under which the presence of a multinational firm may completely eliminate the R&D activities by domestic competitors. When 1) the productivity of the R&İ. λ, is low, 2) the interest rate is high, 3) the technological gap between the domestic and the multinational firms is high and 4) the marginal start-up cost and the fixed cost of R&D is high, there will not be enough incentive for the domestic potential entrant to carry out R&D activity.

We show a sufficient condition such that there exists a unique solution to equation (2.1) in the following lemma.

Lemma 2.1 *If (A.1): $\lambda\pi^D(C^D,\underline{C}^M) > r(F'(0) + \lambda H)$, there exists a unique $\gamma^* \in (0,\infty)$ which solves equation (2.1).*

Proof:

From equation (2.1), we can define these functions:

$$\begin{aligned} U(\gamma) &= \lambda[\pi^D + F(\gamma)] - F'(\gamma)(r + \lambda\gamma) \\ &= f_1^D(\gamma) - f_2^D(\gamma) \end{aligned}$$

where $f_1^D(\gamma) = \lambda[\pi^D + F(\gamma)]$ and $f_2^D(\gamma) = F'(\gamma)(r + \lambda\gamma)$

One can show the following:

$$\frac{dV^D}{d\gamma} \begin{matrix} > \\ < \end{matrix} 0 \quad if \quad U(\gamma) \begin{matrix} > \\ < \end{matrix} 0$$

Since

$$\frac{df_1^D}{d\gamma} = \lambda F'(\gamma) > 0$$

$$\frac{df_2^D}{d\gamma} = \frac{df_1^D}{d\gamma} + F''(\gamma)(r + \lambda\gamma) > 0$$

and $\lambda\pi^D(C^D, \underline{C}^M) > r(F'(0) + \lambda H)$, there exists a unique γ^* which solves the maximization problem of this entrant. Q.E.D.

A.1 can be interpreted as implying that if an innovation occurs, it is productive enough to compete with the best technology available to the multinational firm, and to yield a sufficient profit such that the cost of the flow expenditure of R&D can be covered.

If A.1 does not hold, the domestic firm may or may not do any R&D. Given the existence of a solution, for any C^M, we can represent the R&D intensity of a potential entrant by a function

$$\gamma^* = \gamma^*(C^M)$$

We can also determine the effect of a change in the technology level of the multinational firm on the incentive on the domestic entrant to do R&D from equation (2.1) .

$$\frac{d\gamma^*}{dC^M} = \frac{\lambda\pi^D_{C^M}}{(r + \lambda\gamma^*)F''} \quad > \quad 0 \tag{2.2}$$

Since an increase in the marginal cost of production (i.e., a less advanced technology level) of the multinational firm increases the instantaneous profit of the domestic firm in the duopoly regime, this effect increases the R&D intensity by the domestic potential entrant. The derivative in equaiton (2.2) therefore implies that there is an additional incentive for the multinational firm to adopt a more advanced technology, since this would decrease the expected profit of the domestic potential entrant and thus decrease its expenditure on R&D. This effect would increase the duration of the monopoly regime [19]. We can now explain the significance of assumption D.6: it imposes an upper bound on the effect of the multinational firm's

[19] However, the sign of the second order derivative is ambiguous.

technology level on the R&D intensity of the domestic firm, such that the MNE cannot completely dissuade the potential entrant from undertaking R&D spending by adopting a sufficiently high technology level.

We shall now study the optimization problem of the multinational firm, and then study the conditions under which there exists a unique equilibrium in this game.

2.2.4 The game II: MNE's technology level

Given the reaction function of the domestic entrant, the multinational firm has to decide its technology level so as to maximize its expected profit. (Recall that the MNE already has the technology, but that it is costly to transfer to the LDC). The MNE's expected profit is represented as follows:

$$\begin{aligned} V^M[C^M(X)] &= \int_0^\infty \exp^{-(r+\lambda\gamma^*(C^M))t}[\lambda\gamma^*(C^M)\pi^M(C^M,C^D)/r + R(C^M)]dt \\ &\quad -\rho(X+G_M) \\ &= \frac{\lambda\gamma^*(C^M)\pi^M(C^M,C^D)/r + R(C^M)}{r+\lambda\gamma^*(C^M)} - \rho(X+G_M) \end{aligned}$$

where ρ represents the rate of return to the multinational firm's capital in the rest of the world [20] and G_M represents the set-up cost of a MNE.

Taking the first order derivative of the expected profit with respect to the expenditure on technology transfer, we obtain

$$W(X) = \frac{dV^M}{dX} = C^{M\prime}\left(\frac{\partial V^M}{\partial C^M}\bigg|_{\gamma=\gamma^*} + \frac{dV^M}{d\gamma}\frac{d\gamma^*}{dC^M}\right) - \rho$$

where

$$\frac{d^2\gamma^*}{dC^{M2}} = \frac{\lambda}{F''(r+\lambda\gamma^*)}\left[\pi^D_{C^MC^M} - \pi^D_{C_M}\frac{d\gamma^*}{dC^M}\left(\frac{\lambda}{r+\lambda\gamma^*} + \frac{F'''}{F''}\right)\right] \gtrless 0$$

If the sign of the above derivative is negative, the marginal effect of an increasing technology level on the R&D intensity is increasing with respect to the increasing expenditure on technology transfer. If this second order effect is sufficiently large, the MNE may choose tne best technology level ($\underline{C}^M$) so as the maximize the duration of the monopoly regime. In this case, the solution is a corner solution.

[20] The value of ρ may be different from 1 because of factors such as taxes.

$$\frac{dV^M}{d\gamma} = \frac{\lambda(\pi^M - R)}{(r + \lambda\gamma^*)^2} \quad < \quad 0$$

because the flow of profit R is greater when the MNE is a monopoly, than when the market is a duopoly.

The preceding equations show the incentive for the multinational firm to adopt a more advanced technology. An increase in the expenditure on technology transfer would decrease the marginal cost of production of the multinational firm in both regimes. This is the first marginal benefit. As discussed earlier, a reduction in the marginal cost of production of the multinational firm also decreases the R&D intensity of the domestic entrant, which increases the expected duration of the monopoly regime and thus also raises the expected profit of the multinational firm. This is the second marginal benefit. In equilibrium, the sum of these marginal benefits has to be equal to the marginal opportunity cost of the technology transfer, which is measured by the net-of-tax rate of return to the multinational firm's capital in the rest of the world.

Consider now the question of existence of an interior lead--follower equilibrium. First, C.3 implies that $W(X) > 0$ at $X = 0$. Second, D.5, D.6 and F.4 imply that $\frac{dW(X)}{dX} < 0 \ \ \forall X \in [0, \infty]$. Hence, we can show that the multinational firm's value function is a strictly concave function with respect to the expenditure on technology transfer [21] and then the existence of a unique interior leader-follower equilibrium can be proved. Thus, we have

Proposition 2.2 *There exists a pair of $(X^*, \gamma(C^M(X^*)))$,which solves the m -i-mization problems of both multinational firm and domestic entrant, such that*

1) $0 < X^* < \infty$,

2) $\underline{C}^M < C^M(X^*) < \bar{C}^M$,

3) $0 < \gamma(C^{M*}) < \infty$.

[21]The algebraic expressions of the first and second order conditions for the maximization problem are shown in the appendix.

In the following analysis, we shall assume A.1 (under which there is positive R&D by the potential domestic entrant) is satisfied. One can then show that the MNE's technology level (the R&D intensity of the domestic firm) is higher (lower) in a leader-follower equilibrium than that in a Nash equilibrium [22] since there is strategic incentive for the multinational firm (as a leader) to adopt a higher technology level in order to deter entry of the domestic firm.

2.2.5 Comparative statics

In this section, we consider the effects of changes in some parameters in the model. We shall discuss some policy implications in section 4.

a) An increase in ρ

The opportunity cost ρ of investing in a particular LDC may depend both on the level of world interest rate r, and on the factors such as taxes and regulation in other countries that change the effective return to capital of MNE's invesment in those countries. In this subsection, we focus on these other factors, assuming that r stays constant as ρ changes.

By using the envelope theorem, one can show that an increase in ρ necessarily decreases the expected profit, net of opportunity cost, of the multinational firm:

$$\frac{dV^M(X^*)}{d\rho} = -X^* \quad < 0$$

It also decreases the technology level of the multinational firm. This result can be shown by using implicit function theorem:

[22] If we assume a Nash relation and the existence of a Nash equilibrium, both multinational firm and domestic entrant make their decision simultaneously. A Nash equilibrium (γ_N^*, X_N^*) is defined as:

$$Z(\gamma_N^*; C^M(X_N^*)) = 0$$

and

$$W_N(X_N^*; \gamma_N^*) = \frac{\lambda C^{M\prime}(\gamma_N^* \pi_{C^M}^M / r + R_{C^M})}{r + \lambda \gamma_N^*} - \rho = 0.$$

$$\frac{dX^*}{d\rho} = -\frac{\partial W}{\partial \rho} / \frac{\partial W}{\partial X} \quad < 0.$$

where $W = \frac{dV^M}{dX}$

Since an increase in ρ brings down the technology level of the multinational firm, this change will increase the expected return to the potential domestic entrant of doing R&D. One can easily show that it also increases the expected profit of the domestic entrant and its research intensity. However, it decreases the duration of the multinational firm's monopoly :

$$\frac{dV^D(\gamma^*; C^{M*})}{d\rho} = C^{M\prime} \frac{dX^*}{d\rho} \left(\frac{\lambda \gamma^* \Pi^D_{CM}}{r + \lambda \gamma^*} \right) \quad > 0$$

and

$$\frac{d\gamma^*}{d\rho} = C^{M\prime} \frac{dX^*}{d\rho} \frac{d\gamma^*}{dC^M} \quad > 0.$$

We summarize the above results in the following proposition:

Proposition 2.3 *An increase in the rate of return to the multinational firm's capital in the rest of the world necessarily decreases the expected net-of-opportunity-cost profit, the expected duration of the monopoly, and the technology level of the multinational firm. However, it increases the research intensity and the expected profit of the domestic entrant.*

This result shows that a higher opportunity cost of MNE's capital implies a lower level of foreign technology invesment (lower MNE's technology level), which in turn implies a stimulating effect on the R&D intensity of the domestic firm.

b) An increase in λ

We now discuss the effects of an increase in λ on the MNE's technology level and the domestic competitor's R&D intensity. An increase in λ means that the successful innovation would come earlier if there is no change in γ^*. If there is no change in the technology level of the multinational firm, one can show that there is an increase in the R&D intensity by the domestic entrant.

$$\left.\frac{\partial \gamma^*}{\partial \lambda}\right|_{C^M=constant} = \frac{rF'}{\lambda(r+\lambda\gamma^*)F''} \quad > 0$$

However, there are direct and indirect forces acting on the multinational firm's technology level when λ changes. The indirect effect, caused by an increase in the R&D effort by the domestic entrant, decreases the expected duration of the monopoly and hence the expected profit of the multinational firm. This force leads to an increase in the technology level of the multinational firm in order to decrease the loss.

On the other hand, there are two direct effects, given the R&D intensity of the domestic firm, of a change in λ on the marginal benefit of increasing the expenditure on technology transfer [23]. First, an increase in λ increases the probability of the occurrence of the duopoly regime which increases (decreases) the marginal expected discounted profit from the duopoly (monopoly) regime. According to assumption D.5, the net effect is positive and hence the marginal benefit is increased by this effect. Second, a change in λ also affects the magnitude of the strategic interdependence between the multinational firm and the potential entrant. This second direct effect is composed of two opposing forces. For a given increase in the marginal cost of production of the multinational firm, the potential entrant would increase its R&D intensity more for a higher λ. This is the productivity effect. This effect increases the magnitude of the strategic interdependence between the firms, and thus encourages the multinational firm to spend more on technology transfer. However, an increase in λ also increases the hazard rate (i.e. the expected duration of the duopoly regime), which decreases the marginal benefits of both the potential entrant and the multinational firm in the decisions of choosing the R&D intensity and the technology level. This is the discounting effect which decreases the magnitude of the strategic interdependence. The sign of the second direct effect depends of the size of the interest rate. If the interest rate is sufficiently high , the first effect

[23]The expressions of the derivatives are shown in the appendix.

will dominate the second effect. Specifically, this will be the case if we impose the following assumption: (A.2) : $2r > \lambda\gamma^*(\bar{C}^M)$. We can also show that the change in the R&D technology of the domestic entrant necessarily decreases the expected profit of the multinational firm, by using envelope theorem:

$$\frac{dV^M(X^*)}{d\lambda} = \frac{\gamma^*(\pi^M - R)}{(r + \lambda\gamma^*)^2} \quad < 0$$

However, we cannot determine the changes in the R&D intensity by the domestic entrant since an increase in the technology level of the multinational firm decreases the expected profit of the domestic entrant and thus discourages its R&D activity. [24] Since,

$$\frac{d\cdot_{\prime}}{d\lambda} = \left(C^{M\prime}\frac{\partial Z}{\partial C^M}\frac{\partial W}{\partial\lambda} - \frac{\partial Z}{\partial\lambda}\frac{\partial W}{\partial X}\right)/\frac{\partial Z}{\partial\gamma}\frac{dW}{dX}$$

which implies that

$$\frac{d\gamma^*}{d\lambda} = C^{M\prime}\frac{d\gamma^*}{dC^M}\frac{dX^*}{d\lambda} + \frac{\partial\gamma^*}{\partial\lambda} \quad \begin{matrix} > \\ < \end{matrix} \quad 0$$

We summarize these results in the following proposition:

Proposition 2.4 *A small increase in λ necessarily decreases the expected profit of the multinational firm. It also increases the technology level of the multinational firm if A.2 is satisfied. However, its effect on the research intensity of the domestic entrant, and hence the effect on the expected duration of monopoly are ambiguous.*

This result generates an interesting prediction on the technology levels of MNE in different countries with different research capabilities. In a country with higher

[24]One can determine the effect of a small increase in λ on the R&D intensity by the potential entrant if the difference between the monopoly profit and the oligopoly profit of the multinational firm $(R - \pi^M)$ is sufficiently small. That is, in the neigborhood of $R - \pi^M = 0$ (or the difference between the monopoly profit and the oligopoly profit of the multinational firm is sufficiently small), from equaiton (2 2), one can show that a small increase in λ increases the research intensity of the domestic entrant if

$$(A.3) \cdot \gamma F''/F' < r/[r + \lambda\gamma(\bar{C}^M)].$$

capability, foreign firms may transfer a more advanced technology to its LDC subsidiaries because of the higher probability of entry by domestic competitors due to this higher research capability.

2.3 Licensing of Technology and R&D by Domestic Firms

In this section, we discuss the effects on the R&D intensity of domestic competitor if the foreign firm licenses its technology to some domestic firms. We shall show later that the number of licensees can be used as an instrument of entry deterrence and we further show that the domestic potential entrant may or may not do R&D in a licensing equilibrium.

For the sake of simplicity, we assume the foreign firm makes its decision on licensing (including whether or not to license, and the number of licensees if it does decide to) at t = 0. Although it is interesting to study the timing decision of licensing as an instrument to deter the entry of domestic firm, we are not going to discuss this complicated issue in this simple model. In this case, we also focus on the most simple case in which licensees start their production for $t \geq 0$.

We assume that there is a one-time licensing cost, $L(C^M; n_L)$, which depends on both the technology level of the licensed technology, C^M, and also the number of licensees, n_L, which includes the training cost, the adoption cost, the bureacratic costs [25], legal fees and the additional administration cost. We assume the licensing cost function has the following properties:

(L.1) $\dfrac{dL}{dC^M} \quad < \quad 0,$

(L.2) $\dfrac{d^2L}{dC^{M^2}} \quad > \quad 0,$

(L.3) $L(C^M; n_L + 1) \quad > \quad L(C^M; n_L),$

[25] As mentioned by Marton (1986), "· · · in most countries, centralized technology registries or technology evaluation agencies were established to screen, evaluate, and register technology contracts. · · ·".

(L.4) $L(C^M;0) = G_L \quad > \quad 0 \ \forall \ C^M \in [\underline{C}^M, \bar{C}^M]$.

L.1 and L.2 imply that the licensing cost is increasing at an increasing rate with respect to the technology level being licensed to the domestic firms, since a more advanced technology requires more resources in technology adoption by domestic licensees. L.3 implies that more licensees mean a higher total licensing cost since more resources is needed to deal with more licensees, for example because of legal fees. L.4 implies that there is a fixed cost of licensing, including the cost of lobbying efforts to obtain permission for licensing from government officials.

For the sake of simplicity, we assume the licensor pays all the licensing cost and licensees pay a licensing fee to this foreign firm. If we suppose the licensing contract is sold under perfect competition, the licensee earns zero expected profit evaluated at t = 0. There is a wide variety of licensing agreements in various industries [26]. We are going to discuss two extreme cases. One is a licensing contract with a fixed fee only. In this case, the foreign firm charges the licensees its expected discounted profit at t = 0 . The other case is a contract with royalties only. In this second case, the foreign firm charges a royalty , $\sigma(t) = p(t) - C^M$, per unit of output. Since there are two regimes before and after the occurrence of a successful innovation by the domestic entrant, there are two royalty rates corresponding to these two regimes. If entry by a domestic competitor occurs at $t = t^e$, $p^B \geq p^A$ where $p^B = p(t) \ \ \forall t \ \ \in [0, t^e)$ and $p^A = p(t) \ \ \forall t \ \ \in [t^e, \infty]$. In this case as well, the expected licensing income from future royalty at t = 0 also equals the expected profit of the licensee.

In the following analysis, we restrict our analysis to contracts with a fixed portion of the instantaneous profit of the licensee as the licensing payment. However, the government is assumed to impose an upper bound on the licensing payment [27]. In

[26]Calvert (1964) and Taylor and Silberston (1973) observe that about 50 percent of licensing contracts specify royalties only, 10 percent a fixed fee only, and remaining 40 percent a two-part tariff.

[27]As mentioned by Marton (1986), "$\cdots$ In some countries, maximum permissible royalty rates were prescribed, either for all sectors or at varying rates for different sectors. In others, royalties were approved on a case-by case basis. Since these measures aimed at controlling the outflow of

particular, we suppose host government only allows α of the instantaneous profit of domestic licensees as a licensing fee, where $0 < \alpha < 1$, and the licensees are selected by a random draw [28].

We shall consider two cases. In the first case, we suppose the multinational firm can only license its technology to one domestic firm. In the second case, we allow the multinational firm to choose the number of licensees.

2.3.1 One licensee

The analytic structure in the licensing regime with one licensee is similar to that in the FDI regime. The foreign firm has to decide the technology level of the licensed technology, according to its effects on the domestic competitor's R&D intensity. In this case, the maximum expected profit of the foreign firm from licensing is represented as follows :

$$V_{L1}^M(C_1^{M*}) = \frac{\alpha[\lambda\gamma(C_1^{M*})\pi^L(C_1^{M*}, C^D)/r + R^L(C_1^{M*})]}{r + \lambda\gamma(C_1^{M*})} - \rho L(C_1^{M*}; 1)$$

where $V_{L1}^M(C_1^{M*}) > V_{L1}^M(C^M) \;\; \forall C^M \in [\underline{C}^M, \bar{C}^M]$ and $\pi^L(C_1^{M*}, C^D)$ and $R^L(C_1^{M*})$ are the instantaneous profit flows of the licensee in the duopoly and monopoly regimes, respectively.

We simply assume that there exists a unique equilibrium to maximize the above objective function, and that the marginal benefit of adopting a more advanced technology is a decreasing function of the level of the licensed technology [29]. We shall first compare the technology level of the MNE in the FDI regime, $C^M(X^*)$, and the technology level of the licensee, C_1^{M*}.

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foreign exchange and reducing the evasion of local taxes, ..."

[28] Since α is less than one, there is a positive profit of being a licensee. In this case, there is an excess supply of licensees. A random draw is one mechanism to allocate the license and corruption may be another possible allocation mechanism in some LDCs.

[29] An equilibrium can be shown to exist if we assume similar conditions as we did in section 2, plus (1) $L_1(\bar{C}^M, n_L) = 0$ and (2) $L_1(\underline{C}^M, n_L) = \infty$.

Proposition 2.5 *If* $(L.5): -\frac{dL(C^M(X^*);1)}{dC^M} > -\frac{\alpha}{C^{M\prime}(X^*)}$, *the technology level of the MNE in the FDI regime is higher than that of the licensee in the licensing regime. On the other hand, the R&D intensity of the potential entrant in the FDI regime is lower than that in the licensing regime.*

Proof: The above proposition is implied from our assumption of the decreasing net marginal revenue of licensing a more advanced technology. Q.E.D. .

Proposition 2.5 implies that the MNE's technology level will be higher than the licensee's technology level if the marginal adoption cost of a more advanced technology is lower in the FDI regime in comparison with that in a licensing regime, evaluated at the optimal technology level of the MNE in the FDI regime. There may be three reasons why this condition may hold. First, suppose we think of the MNE in the previous section as a foreign parent firm with an LDC subsidiary. The cost (both marginal and total) of adoption of technology in the FDI regime may then be lower than that in a licensing regime since it is easier to transfer technology through an MNE's parent-subsidiary link, in comparison with the transfer of technology from a foreign firm to a licensee in an LDC. Second, the administrative cost may be higher for a more advanced technology in a licensing regime than in the FDI regime, since a more advanced technology requires more resources to specify and to enforce the licensing contract. Third, the cost may also be different due to the differences in government policy with respect to direct foreign investment and licensing, respectively. Since we suppose there is no tax imposed on the MNE in the FDI regime, α can measure the magnitude of the restriction on licensing payment in comparison with any restriction on the outflow of profits from the MNE [30]. In this case, a sufficiently low α may also imply a higher technology level in FDI regime. A low α means that the government perfers FDI to licensing of technology. If there is

[30]Note that with this interpretation, it would be possible for $\alpha > 1$.

no difference in the restriction on the outflow of profit from MNE or licensees (i.e. $\alpha = 1$), the first and second forces alone will determine whether L.5 holds. However, the host government may discourage the setting up of MNEs for various reasons, and then a high α as a policy parameter is implied. In this case, the third force is working against the first and second forces, and we cannot predict know the relative technology level in these two regimes.

We shall first compare the welfare level in the licensing regime with the welfare level in the FDI regime, by assuming L.5 is satisfied. Suppose, in particular that, we measure welfare by adding up the discounted instantaneous consumer surplus (CS) and the expected profit of the domestic firms (DP), i.e. both the licensees' and the potential entrant's profits. First, proposition 2.5 implies that the DP in the licensing regime is higher than that in the FDI regime since the expected profit of the domestic entrant is increased (because of a dominant firm's less advanced technology level), and also there is positive profit earned by the licensee. However, the effect on CS is ambiguous in the licensing regime, in comparison with the FDI regime, since the technology level of the dominant firm (licensee) is lower, but the duration of the monopoly regime is shorter than that in the FDI regime. The first force decreases the discounted sum of CS, and the second force increases it. The net effect depends on the magnitude of the interest rate and the difference in instantaneous CS between the monopoly and duopoly regimes under licensing. If the interest rate is low and the difference is high , we may expect a positive effect on CS. In this case, welfare in the licensing regime will be higher. The aggregate welfare implication of licensing will be ambiguous if the discounted sum of CS decreases. However, in that case, there is unambiguously a transfer of welfare from consumers to producers if the foreign firm chooses licensing instead of FDI.

From the expression L.5 in proposition 2.5, one can see how the upper bound on the licensing payment affects the technology level. We shall discuss how changes in this policy parameter affects the licensing equilibrium in next section.

2.3.2 More than one licensee

In this subsection, we are going to discuss how the foreign firm can discourage R&D by domestic competitors through licensing its technology to more than one firm. We keep the assumption of Nash-Cournot competition among domestic firms (including licensees and the other firm) in the final good market. (If all licensees were to act in collusion instead, the analytic structure would be the same as in the single licensee case.)

If the foreign firm licenses the technology to n_L domestic firms, we use $\pi^D(C^D, C^M; n_L)$ and $\pi^L(C^M, C^D; n_L)$ to represent the instantaneous profit of the domestic entrant and each licensee, after the occurrence of a successful innovation respectively. On the other hand, we use $\pi^L(C^M; n_L)$ to represent the instantaneous profit level of each licensee before the entry by a non-licensed domestic firm.

We assume that the instantaneous profit level of each domestic firm (entrant and licensee) decreases as the number of licensees increases. From this property, we know that there exists a critical number of licensee, $\hat{n}_L$, for a given C^M, such that there is no R&D by the potential entrant:

$$\pi^D(C^D, C^M; \hat{n}_L(C^M)) \quad < \quad r(F'(0)/\lambda + H) \quad \leq \pi^D(C^D, C^M; \hat{n}_L(C^M) - 1) \tag{2.3}$$

Hence, the foreign firm could eliminate the domestic potential entrant by licensing its technology to a sufficiently large number of domestic firms, if this strategy were to generate the highest expected profits. One can show that this critical number of licensees depends on the technology level of the licensed technology. A more advanced technology level implies a lower critical number of licensees, since the foreign firm needs a smaller number of more competitive licensees in order to completely eliminate the R&D activities by the potential domestic entrant.

If the number of licensees increases, there are two effects on the total instantaneous licensing payment to the foreign firm. The first effect is a positive effect since there is one more licensee paying a licensing fee to the licensor. On the other hand, the instantaneous profit of each licensee also decreases since there is one more competitor in the market. In order to highlight the entry deterrence purpose of licensing, we further assume that

(D.7) : $(n_L + 1)\pi^M(C^M, C^D; n_L + 1) < (n_L)\pi^M(C^M, C^D; n_L) \;\; \forall \;\; n_L \geq 1$ and

(D.7') : $(n_L + 1)\pi^M(C^M; n_L + 1) < (n_L)\pi^M(C^M; n_L) \;\; \forall \;\; n_L \geq 1.$

D.7 and D.7' imply that the sum of all instantaneous profits of licensees is decreasing with respect to the total number of licensees. According to this assumption, the only incentive for the foreign firm to increase the number of licensees is to decrease the R&D intensity of the potential non-licensed domestic competitor. One can easily show that the equilibrium R&D intensity by the potential entrant depends on the number of licensees. That is, for $n_L < \hat{n}_L$:

$$\frac{d\gamma^*}{dn_L} < 0.$$

Since an increase in the number of licensees, other things being constant, decreases the expected profit of the potential entrant, there will be a decrease in the R&D intensity of potential entrant.

Consider now first the case in which the best strategy is such that there is positive R&D intensity by the domestic competitor. In this case, the foreign firm licenses its technology to n_L^* ($n_L^* = 1$ corresponds to the case in previous subsection) domestic firms. We call this strategy **S2**. We use $V_2^M(C_2^{M*}; n_L^*)$ to represent the expected payoff to the foreign firm of this strategy:

$$\begin{aligned} V_2^M(C_2^{M*}; n_L^*) &= \frac{\alpha n_L^*[\lambda\gamma^*(C_2^{M*}; n_L^*)\pi^L(C_2^{M*}, C^D; n_L^*)/r + \pi^L(C_2^{M*}; n_L^*)]}{r + \lambda\gamma^*(C_2^{M*}; n_L^*)} \\ &\quad -\rho L(C_2^{M*}; n_L^*) \end{aligned}$$

where (n_L^*, C_2^{M*}) satisfies:

$$V_2^M(C_2^{M*}; n_L^*) \geq V_2^M(C_2^{M*}; n_L) \ \ \forall n_L \in [1, \hat{n}_L(C_2^{M*}))$$

$$V_2^M(C_2^{M*}; n_L^*) \geq V_2^M(C^M; n_L^*) \ \ \forall C^M \in [\underline{C}^M, \bar{C}^M]$$

In this case, there is R&D by the potential entrant, and hence there are two regimes. In the first regime, only the domestic licensees are suppliers in the market. After the occurrence of a successful innovation, there will be one more domestic firm in the market. However, the duration of the first regime depends on both the licensed technology level (C^M), and also on the foreign firm's choice of the total number of licensees, since both of them affect the equilibrium R&D intensity by the potential entrant.

Second, we discuss the case when the foreign firm licenses its technology to a sufficiently large number of licensee such that there is no R&D by potential entrants. We call this strategy **S3**.

Suppose $V_3^M(C_3^{M*})$ denotes the expected profit of the multinational firm if $n_L = \hat{n}_L(C_3^{M*})$:

$$V_3^M(C_3^{M*}) = \frac{\alpha \hat{n}_L(C_3^{M*})\pi^L(C_3^{M*}; \hat{n}_L(C_3^{M*}))}{r} - \rho L(C_3^{M*}; \hat{n}_L(C_3^{M*}))$$

where C_3^{M*} and $\hat{n}_L(C_3^{M*})$ satisfies (2.3) and the following condition

$$V_3^M(C_3^{M*}) \ \ \geq \ \ V_3^M(C^M) \ \ \forall C^M \ \ \in [\underline{C}^M, \bar{C}^M]$$

In this case, there will be no potential entrant and hence the expected profit of the foreign firm from licensing equals α times the discounted profit of its licensees minus the cost of licensing.

We simply assume $V_2^M(C_2^{M*}; n_L^*)$ and $V_3^M(C_3^{M*})$ exist and the corresponding solutions (C_2^{M*}, n_L^*) and C_3^{M*} are unique. We use $V^M(X^*)$ to denote the maximum profit of the multinational firm in the equilibrium in the FDI regime. The strategy of the foreign firm depends on the relative magnitudes of V^M, V_2^M and V_3^M. There are three possibilities.

1) If $V^M(X^*) \quad > \quad Max[V_2^M(C_2^{M*}; n_L^*), V_3^M(C_3^{M*})]$, the foreign firm will choose to set up a multinational firm (FDI) without licensing .

2) If $V_2^M(C_2^{M*}; n_L^*) \quad > \quad Max[V_3^M(C_3^{M*}), V^M(X^*)]$, the foreign firm will license its technology to n_L^* domestic firms and there is positive R&D activity by the potential entrant.

3) If $V_3^M(X_3^*) \quad > \quad Max[V_2^M(C_2^{M*}; n_L^*), V^M(X^*)]$, the foreign firm finds it more profitable to license its technology to a sufficiently large number of licensee such that there will be no R&D by the potential entrant.

We shall first discuss the determinants behind case 2) and case 3). Suppose the technology level of licensees in **S2** is the same as in **S3**. According to D.7 and D.7', the adoption of **S3** leads to a decrease in the aggregate instantaneous profit (in comparison with the profit level before the occurrence of a successful innovation if the foreign firm adopts **S2**), and the payment of a higher licensing cost for any given licensed technology level . However, the licensee's instantaneous profit in **S3** may be higher than that in **S2** after the occurrence of a successful innovation. Hence, we cannot compare the profit levels in general but we are going to show that the foreign firm never adopts **S3** under certain conditions.

Suppose the foreign firm adopts C^M for both **S2** and **S3**. One can show the following:

$$V_3^M(C^M) - V_2^M(C^M; n_L) = \delta_1^L + \frac{\alpha[\lambda\gamma(C^M; n_L)\delta_2^L + r\delta_3^L]}{r(r + \lambda\gamma(C^M; n_L))}$$

where $\delta_1^L = L(C^M; n_L) - L(C^M; \hat{n}_L(C^M))$

$\delta_2^L = [\hat{n}_L(C^M)\pi^L(C^M; \hat{n}_L(C^M)) - n_L\pi^L(C^M, C^D; n_L)]$ and

$\delta_3^L = [\hat{n}_L(C^M)\pi^L(C^M; \hat{n}_L(C^M)) - n_L\pi^L(C^M; n_L)]$.

For $C_2^M = C_3^M$, δ_1^L measures the saving in the licensing cost by adopting **S2** instead of **S3** since the number of licensees in **S2** is less than that in **S3**. δ_3^L measures the difference in the sum of all licensees' instantaneous profits in S3 on the one hand, and before the occurrence of a successful innovation in S2 on the other hand. One can show that this term is always negative according to the property of $\hat{n}_L$ and D.7. δ_2^L measures the difference in the sum of all licensees' instantaneous profits in S3 and that in S2 after the occurrence of a successful innovation. The sign of this difference is uncertain. It depends in part on the difference of C^D and C^M. If the difference is high (low), the sign is likely to be negative (positive). A sufficient condition of δ_2^L to be negative is

$$
\begin{aligned}
(D.8) \quad : \quad & \hat{n}_L(C^M)\pi^L[C^M;\hat{n}_L(C^M)] \\
\leq \quad & (\hat{n}_L(C^M)-1)\pi^L[C^M,C^D;\hat{n}_L(C^M)-1] \quad \forall C^M \in [\underline{C}^M,\bar{C}^M]
\end{aligned}
$$

From the above discussion, we have the following proposition:

Proposition 2.6 *If D.8 is satisfied, there is positive R&D intensity by the potential entrant if the foreign firm adopts licensing instead of FDI.*

Proof: Suppose C_3^{M*} maximizes V_3^M. From the above proposition, one can always find a $n_L < \hat{n}_L(C_3^{M*})$ such that $V_2^M(C_3^{M*};n_L) > V_3^M(C_3^{M*})$ if D.8 is satisfied. From the definition of $V_2^M(C_2^{M*};n_L^*)$, the foreign firm will not choose S3 under D.8. Q.E.D.

The above proposition implies that we will not observe an equilibrium in which there has been a complete elimination of the domestic competitor's R&D through licensing, if the foreign firm expects a sufficiently low quality innovation from the domestic firm (i.e., if C^D is high enough so that D.8 holds).

We turn next to a discussion of the choice by the foreign firm between FDI or licensing. One can expect that the determinants of the outcome will depend on a) the magnitude of the set-up cost for MNE, b) the magnitude of the licensing cost and c) the responsiveness of γ^* t$\cdot$ 'he a change in n_L. If the licensing cost is sufficiently high , FDI is likely to be .ne equilibrium strategy. Licensing will be the equilibrium strategy if the responsiveness of the expected duration of the monopoly to the change in n_L is high, and also the set-up cost for an MNE subsidary is high. In general, we cannot compare the technology level of the multinational firm in the FDI regime, and the technology level of the licensees in the licensing regime in the absence of further information. Thus we cannot provide an ambiguous welfare comparison of these two regimes.

If we neglect the change in technology level, in comparison with the FDI regime, there are three potential factors which may affect the welfare. One is the positive efect on CS in the presence of more competitors (licensees). The other is the increase in the duration of monopoly which tends to decrease the CS. However, the additional licensees' profit also contributes to domestic welfare in comparison with the welfare in the FDI regime.

2.4 Effects of Technology Policies

In this section, we discuss the effects of different technology policies. First, we consider the effects of two kinds of technology policies in the FDI regime. One is a subsidy to the domestic entrant's research activities; the other is a subsidy to technology transfer by the multinational firm [31] . Second, we discuss the effects of an increase in the upper bound on licensing payment in a licensing regime with one licensee.

[31] The presence of spillovers may be the reason for the host government to adopt this policy. Although we do not consider the effect of spillovers in this model, the following policy analysis studies some other possible consequence of this policy.

2.4.1 Technology policies in FDI regime

Suppose government starts paying a small subsidy to the R&D activity by the domestic entrant. The expected profit function of the domestic entrant may then be represented by:

$$V^D(\gamma; C^M, S^D) = \frac{\lambda\gamma^* \Pi^D - (1 - S^D)F}{r + \lambda\gamma^*} - H$$

where S^D is the rate of subsidy to the R&D activity by the domestic entrant.

One can show that

$$\left.\frac{\partial\gamma^*}{\partial S^D}\right|_{S^D=0, C^M=constant} = (r + \lambda\gamma)F' - \lambda F \quad > 0$$

The first round effect of this subsidy leads to an increase in the R&D intensity by the potential entrant if there is no change in the technology level of the multinational firm. In this case, there would be a decrease in the duration of the monopoly regime.

We turn next to study the effects of this kind of policy on the multinational firm's technological decision, i.e. its choice of X. We can show that there will be an increase in the technology level, as the MNE tries to decrease the loss brought by this change. However, there will be a decrease in the expected profit of the multinational firm, even after the adjustment in the technology level, since [32]

$$\left.\frac{dX^*}{dS^D}\right|_{S^D=0} = \frac{\partial X^*}{\partial\gamma}\frac{\partial\gamma^*}{\partial S^D} \quad > 0$$

and then we can get the following result by applying the envelope theorem:

$$\left.\frac{dV^M(X^*)}{dS^D}\right|_{S^D=0} = \frac{dV^M(X^*)}{d\gamma}\frac{\partial\gamma^*}{\partial S^D} \quad < 0$$

After the multinational firm increases its expenditure on technology transfer, we can show that there will be a second round increase in the R&D intensity by the domestic entrant. The ultimate effect of S^D on the expected profit of the domestic entrant is ambiguous since the second round effect decreases its expected profit [33]

[32] One can derive the following result from the total derivative of the first order condition of the MNE's maximization problem, with respect to S^D.

[33] One can derive the following result from the total derivative of the first order condition of the potential entrant's maximization problem, with respect to S^D.

$$\frac{d\gamma^*}{dS^D}\bigg|_{S^D=0} = \frac{\partial\gamma^*}{\partial S^D}\frac{\partial W}{\partial X}/\frac{dW}{dX} \quad > 0$$

and

$$\frac{dV^D(\gamma^*)}{dS^D}\bigg|_{S^D=0} = \left(F + C^{M\prime}\lambda\gamma^*\Pi^D_{CM}\frac{dX^*}{dS^D}\right)/(r+\lambda\gamma^*) \ \gtreqless \ 0$$

We can summarize the above results in the following proposition.

Proposition 2.7 *If government starts imposing a small sudsidy on the R&D activities by the domestic entrant, at t = 0, this policy increases the technology level of the multinational firm and also the research intensity of the domestic entrant. It also decreases the expected profit and the expected duration of the monopoly of the multinational firm. However, its net effect on the expected profit of the domestic entrant is ambiguous.*

Consider now the welfare implications of this policy. As shown in the above proposition, a small subsidy on R&D by the domestic potential entrant increases the technology level of the multinational firm, which will increase the quantity supplied in both the monopoly and duopoly regimes. This has a positive effect on the consumer surplus in both regimes. On the other hand, the duration of the monopoly regime also decreases. This effect further increases CS if we assume that the instantaneous CS in the duopoly regime is higher than that in the monopoly regime. As we have shown in the earlier analysis, the effects of the subsidy on the domestic entrant's profit is ambiguous. Hence, we cannot sign the net effect on welfare of this subsidy. If DP is decreased, this policy decreases the welfare of the domestic producer but increases the welfare of domestic consumers.

We turn next to a study of the effect of a small subsidy on technology transfer by the multinational firm. If government starts to pay this subsidy, the effect would be the same as that of a decrease in the opportunity cost of the multinational firm's capital. The expected profit of the multinational firm can be represented as:

$$V^M(X, S^M) = \frac{\lambda\gamma\pi^M/r + R}{r + \lambda\gamma^*} - \rho[(1 - S^M)X + G_M]$$

One can show the following proposition easily by using the same kind of argument as we did for proposition 2.3.

Proposition 2.8 *If government pays a small subsidy on technology transfer by the multinational firm, this necessarily increases the expected profit, the expected duration of the monopoly, and the technology level, of the multinational firm. However, it decreases the research intensity and the expected profit of the domestic entrant.*

Turning to welfare analysis, a small subsidy on technology transfer by the multinational firm decreases the expected profit of the domestic entrant; that is it decreases DP. On the other hand, it increases the technology level of the multinational firm and hence increases the CS in both regimes. However, the duration of the monopoly regime is also increased by this policy. In general, we cannot determine the net change in CS and hence its net effect on welfare. As we have discussed earlier, one may expect a decrease in the discounted sum of CS if the discount rate is small and the difference in the instantaneous CS between the monopoly regime and the duopoly regime is large. In such a case, the subsidy on technology transfer to the MNE is a welfare-reducing policy [34].

2.4.2 Technology policies in licensing regime

As mentioned by Marton (1986), governments in LDCs implement various measures to regulate technology agreements between domestic firms and foreign firms. One of them is restriction on the magnitude of the licensing payment. We are going to discuss the effects of a decrease in the upper bound, α, on licensing payments from local licensees. We only consider the case in which there is only one licensee.

[34] In the above analysis, we neglect the direct negative effect on welfare by the subsidy itself since the MNE takes away some resources in the form of subsidy.

Because of our assumption of decreasing marginal benefit with respect to increasing technology level, the effects of this policy will be similar to those of a decrease in the upper bound on the outflow of instantaneous profit from an MNE (hence, a larger portion of instantaneous profit is allowed to be taken away as licensing payment in the licensing regime, or as an outflow of profits from MNE in the FDI regime).

Suppose there is an increase in the upper bound on the allowable licensing payment. One can show that *the technology level of the licensed technology will be increased and also the R&D intensity of the domestic potential entrant will be decreased.* The intuition behind this result is clear since an increase in the upper bound on licensing payment increases the marginal benefit for the foreign firm to license a more advanced technology. However, this improvement in the licensee's technology level decreases the incentive for the domestic potential entrant to do R&D. The welfare implication of this change in policy is again ambiguous. First, the policy change decreases the expected profit of the licensee. Moreover, it also decreases the expected profit of the potential entrants. Hence, its effect on the DP is negative. Second, however, the instantaneous CS in the monopoly regime increases as a result of the more advanced technological level after the change. On the other hand, the duration of the monopoly regime increases. Thus we cannot derive unambiguous welfare implications in general. What can be said is only that we may expect a decrease in welfare if the discount rate is low and the difference in the instantaneous CS between the monopoly regime and the duopoly regime is large. In this case, this policy is a welfare reducing policy. Hence, this result may provide support for the practice of some LDCs to limit the outflow of profits as licensing payments from licensees, or from the MNE directly in the FDI regime.

2.5 Concluding Remarks

We shall first provide a summary of the policy implications of this model, and then we are going to discuss some possible comments and extensions of the work.

In this paper, we have discussed the relation between the technology level of the MNE in an FDI regime (or of the licensee in a licensing regime), and the R&D intensity of domestic potential competitors . In the absence of spillovers, the foreign firm has an incentive to transfer a more advanced technology (to either the MNE in the FDI regime or to licensees in the licensing regime) in order to reduce the R&D intensity of potential domestic competitors.

We have also discussed the effects of some technology policies. In an FDI regime, we have shown that a small R&D subsidy to the domestic firm can increase its R&D intensity, and also that it will increase the technology level of the MNE. This policy necessarily increases the discounted sum of instantaneous consumer surplus, but its effect on the expected profit of the domestic competitor is ambiguous. If the domestic producer's expected profit is decreased, the policy implies a transfer of welfare from producers to consumers. However, a small subsidy on technology transfer necessarily increases the technology level of the MNE and decreases the R&D intensity of the domestic firm. This policy may be a welfare-reducing policy under certain conditions since the duration of the monopoly regime is increased and the expected profit of the domestic competitor is decreased. Under these conditions, a tax on technology transfer may be welfare-improving.

Some governments in LDCs limit the payment for technology transfer through licensing. We have shown that an increase in the regulated licensing payment can increase the level of the licensed technology, but it decreases the R&D intensity of the domestic firm. However, this policy may be welfare-reducing under certain conditions since the duration of the monopoly regime of the licensee is increased, and also the expected profits of domestic firms (both licensee and non-licensee) are decreased. We have also established that an increase in the number of licensees for the same technology can be used as a tool to discourage R&D by domestic competitors.

The presence of technology spillovers from multinational firms is widely documented in the literature. One possible extension of the model is the incorporation of spillovers from either the MNE or from licensees. In the presence of spillovers, the productivity (in the production of final goods or in R&D) of domestic competitors can be increased. One may expect that most of the results in the above analysis will continue to hold if the degree of spillover is low. However, a high degree of spillover may discourage the foreign firm from transferring a more advanced technology to LDCs, since the competitive power of local firms can be increased by these spillover effects. On the other hand, we may get different policy implications in the presence of spillovers. For an example a subsidy to the MNE's technology transfer may increase the domestic competitor's R&D intensity in the presence of a high degree of spillover, since this subsidy increases the MNE's technology level and domestic R&D is encouraged through spillover effects.

Another critical assumption of this model is the presence of only one domestic potential entrant. One can allow free entry to R&D activities , and let the number of domestic potential entrants be determined by a zero profit constraint. In this case, a more advanced technology of the MNE not only can decrease the R&D intensity of each potential entrant, but also decreases the number of potential entrants in a free entry equilibrium.

Another critical feature of the model is the specification of the R&D process. We have adopted a specification of the R&D process which is common in the literature, namely to assume that the outcome of the R&D is fixed, but the expected arrival date of the innovation is affected by the expenditure on R&D. This simple feature neglects the impact of R&D expenditure on the quality of any resulting innovations, but it does capture the dynamic nature of R&D. One could modify the model by adopting a two-period framework in which the potential entrant knows that there will be a successful innovation at the begining of the second period, but in which the nature of this successful innovation depends on its R&D expenditure in the first period. We would expect similar results from such a modified set-up.

Appendix 2.A

In this appendix, we are going to show the first order and second order conditions of the maximization problem of the multinational firm in section 2.2.

We can derive the following from the definition of V^M:

$$W(X) = \frac{dV^M}{dX} = \frac{\lambda C^{M'}}{r + \lambda\gamma^*}\left[\gamma^*\pi^M_{CM}/r + R_{CM}/\lambda + \frac{\lambda(\pi^M - R)\pi^D_{CM}}{(r+\lambda\gamma^*)^2 F''}\right] - \rho$$

and

$$\frac{dW(X)}{dX} = \frac{d^2V^M}{dX^2} = \left.\frac{\partial W(X)}{\partial X}\right|_{\gamma=\gamma^*} + C^{M'}\frac{dW(X)}{d\gamma}\frac{d\gamma^*}{dC^M} \gtreqless 0$$

where

$$\begin{aligned}\left.\frac{\partial W(X)}{\partial X}\right|_{\gamma=\gamma^*} = & \left[\frac{(C^{M'})^2}{r+\lambda\gamma^*}\right]\Big\{\lambda\gamma^*\pi^M_{CMCM}/r + R_{CMCM} \\ & + \frac{\lambda^2[(\pi^M_{CM} - R_{CM})\pi^D_{CM} + (\pi^M - R)\pi^D_{CMCM}}{(r+\lambda\gamma^*)^2 F''}\Big\} \\ + & \frac{C^{M''}}{r+\lambda\gamma^*}\left[R_{CM} + \lambda\gamma^*\pi^M_{CM}/r + \frac{\lambda^2(\pi^M - R)\pi^D_{CM}}{(r+\lambda\gamma^*)^2 F''}\right]\end{aligned}$$

and

$$\frac{W(X)}{d\gamma} = \frac{\lambda C^{M'}}{(r+\lambda\gamma^*)^2}\left[\pi^M_{CM} - R_{CM} - \frac{\lambda(\pi^M - R)\pi^D_{CM}}{(r+\lambda\gamma^*)F''}\left(\frac{3\lambda}{r+\lambda\gamma^*} + \frac{F'''}{F''}\right)\right]$$

From above expressions, one can easily show that D.3, D.6 and F.4 implies that $\frac{dW(X)}{dX} < 0$.

Appendix 2.B

In this appendix, we are going to show the effect of an increase in λ.

From the definition of $W(X)$:

$$\frac{dW(X)}{d\lambda} = \left.\frac{\partial W(X)}{\partial\lambda}\right|_{\gamma=\gamma^*} + \left.\frac{dW(X)}{d\gamma}\frac{\partial\gamma^*}{\partial\lambda}\right|_{C^M=C^{M*}}$$

where

$$\frac{\partial W(X)}{\partial \lambda} = \frac{C^{M'}}{(r + \lambda\gamma^*)^2}\left[\gamma^*(\pi^M_{CM} - R_{CM}) + \frac{(\pi^M - R)\pi^D_{CM}\lambda(2r - \lambda\gamma^*)}{(r + \lambda\gamma^*)^2 F''}\right]$$

and

$$\frac{\partial \gamma^*}{\partial \lambda} \quad > \quad 0$$

One can see that $\dfrac{\partial W(X)}{\partial \lambda} > 0$ if A.2 : $2r > \lambda\gamma^*(\bar{C}^M)$. Under A.2,

$$\frac{dX^*}{d\lambda} = -\frac{dW}{d\lambda} / \frac{dW}{dX} \quad > \quad 0$$

Chapter 3

Resource Allocation, Lobbying Activities, and the Allocation of Public Intermediate Good

3.1 Introduction

Since the seminal contributions by Tullock (1967) and Krueger (1974), there are many papers which study the theory of rent-seeking behaviour and its relation with the formulation of policy [1]. However, we know of no attempt to model the rent-seeking behaviour in the process of the allocation of public intermediate good among different sectors, even through this process may be one important factor for understanding sectoral development, and the aggregate growth rate in LDCs. This paper attempts to address several issues in this area. [2].

Public intermediate good include infra-structure, public research and education.

[1]One can find literature in the fields of endogenous tariffs (Bhagwati and Srinivasan (1980); Findlay and Wellisz (1984) Magee, Brock, and Young (1989)); corruption (Blomqvist and Mohammad (1986)); regulation of monopoly (Hillman and Katz (1984)) as well as a huge amount of literature in the field of public choice.

[2]With respect to the modelling of the rent - seeking behaviour, the main difference between this work and some recent works on endogenous trade policy, for example Magee, Brock and Young (1989) and Hillman and Ursprung (198?), is the structure of the policy game. In most of the works on endogenous trade policy (one exception is Findlay and Wellisz (1984)), the policy game is played among capitalists and labor union, which seems to be more suitable to describe the political economy in developed countries. In this paper, we change the structure of the game such that the players are capitalists and landlords, which is a more reasonable feature for most developing countries. As we are going to show later, the specific factor model is not a trivial modification of the standard two factors (capital and labor) model.

Only sector-specific public intermediate good are considered here. It is not difficult to see the importance of the provision of sector-specific public intermediate good in the process of economic development [3]. One type of sector-specific public intermediate good is the R&D activity carried out by government, which includes two types of public reseach. One is the public research which can improve productivity in the manufacturing sector; another is the public research which can improve productivity in the agricultural sector . This kind of public intermediate good is particularly important in determining the patterns of technological change in LDCs, which are generally characterized by relatively low research capability. In LDCs, government has to play a more important role in doing R&D than that of the private sector since R&D requires a high initial cost and a relatively high general level of research capability.

However, it is plausible to postulate that the allocation of this kind of public intermediate good is affected by lobbying behaviour [4]. In this work, we consider resource allocation in the presence of lobbying activities affecting the allocation of a given government budget for supplying sector-specific public intermediate good to two sectors [5].

There are two 'real' effects from this kind of rent-seeking behaviour. One is the possible distortion (in both static and dynamic senses) caused by the misallocation of resources. The other is the direct resource loss from this kind of behaviour (the

[3]The development of the industrial sector is considered as an engine of growth by many economists. As mentioned by Meier (1989 p.358), " ··· industrialization offers substantial dynamic benefits that are important for changing the traditional structure of the less developed economy, and the advocacy of industrialization may be particularly compelling for primary export countries that confont problems of a lagging export demand while having to provide employment for a rapidly increasing labor force.···".

[4]According to Pineiro and Trigo (1983), the patterns of productivity changes in Latin America could be explained by collective action, e.g. lobbying for the allocation of public research.

[5]Although this kind of rent-seeking behaviour is important for determining the patterns of technological change and hence economic growth, there is no attempt to study this dynamic relation in this work. However, this paper will, hopefully, improve our understanding of this kind of behaviour in a static framework, which, in turn, may be useful in further work to investigate the important dynamic relationships.

opportunity cost of the resources used in lobbying). It has been estimated that the resource loss from rent - seeking constitutes a larger portion of GNP in LDCs, relative to those in developed countries [6].

This paper provides a simple general equilibrium model to study the relation among lobbying behaviour, resource allocation and the allocation of public intermediate good. We adopt a specific factor model in which capitalists and landlords can influence the allocation of public intermediate good by using lobbying effort. Labor can be used either as a direct input in the production process, or used in lobbying, to influence the government's allocation policy. Thus, the presence of lobbying not only represents a form of resource loss, but also indirectly influences employment decisions in each sector, through its effect on the availability of public intermediate good. It also affects the wage rate. We shall demonstrate these relations in a general equilibrium model. The effects of certain other government policies on the lobbying intensity, and hence the allocation of public intermediate good , will also be discussed.

In section 2, we shall discuss the basic environment. The properties of the general equilibrium will be discussed in section 3. The effects of other government policies , e.g. production subsidies, or an increase in the total government budget for public intermediate good, on the allocation of public intermediate good, will be discussed in section 4. Section 5 will provide concluding remarks.

[6]Although rent - seeking in the context of lobbying for tariffs or favourable legislation has been extensively analysed, as Katz and Rosenb rg (1989) mention, "consideration of the government's budgetary activity in the light of rent seeking theory has been very limited". They provide a preliminary estimation for the resource loss from rent seeking activity induced by budget allocation process, according to which Israel and Egypt lose more than five per cent of GNP in such activity.

3.2 The Basic Environment and the First Best Allocation

There are three sectors, namely the manufacturing sector, the agricultural sector and the public sector, in this small open economy. The country is small and faces an international price P^* for the manufactured good. The numeraire is the agricultural good, assumed to be the more labor-intensive good. Both goods are produced by using a specific factor (land for the production of agricultural goods and capital for the production of manufactured goods) , labor, and a sector-specific public intermediate good. The use of the public intermediate good in the production of final good has the non-excludability property within each sector. On the other hand, both capital, land, and labor markets are perfectly competitive and the economy is endowed with $\bar{L}$ amount of labor, $\bar{D}$ amount of land and $\bar{K}$ amount of capital.

We assume the production functions in agriculture and manufacturing are of the Cobb-Douglas [7] form:

$$M = F(L_M, I_M, K_M) = \sigma_M I_M^{\delta_M} L_M^{\alpha_M} K_M^{1-\delta_M-\alpha_M}, \; 1 > \delta_M + \alpha_M > 0; \sigma_M > 0$$

$$A = G(L_A, I_A, D_A) = \sigma_A I_A^{\delta_A} L_A^{\alpha_A} D_A^{1-\delta_A-\alpha_A}, \qquad 1 > \delta_A + \alpha_A > 0; \sigma_A > 0$$

where M (A) is the production of the manufactured (agricultural) good, $I_M(I_A)$ is the amount of public intermediate good supplied to the manufacturing (agricultural) sector, $K_M(D_A)$ is the amount of capital (land) employed in the manufacturing (agricultural) sector, $L_M(L_A)$ is the amount of labor employed in the manufacturing (agricultural) sector, $\sigma_M(\sigma_A)$ is the productivity parameter in the production of the manufactured (agricultural) goods.

Public intermediate good (I_M or I_A) are produced in the public sector by the

[7] Magee, Brock and Young (1989) also assume Cobb-Douglas production functions in their study on the determination of endogenous tariffs.

government. One unit of either I_M or I_A is produced by using one unit of capital [8]. Government pays the capital-owner at the market rate. In order to highlight the effects of lobbying activities, we assume this payment is financed by non-distortionary taxation on the consumption side.

There are two stages in the government decision. First, the government decides the total amount of pubic intermediate good (B) [9]. Second, the government will allocate the public intermediate good between sectors according to a policy rule (λ_M), which specifies the share of the total budget that is allocated to the manufacturing sector. Specifically, we assume

$$\lambda_M = P(L^l_M, L^l_A)$$

and then

$$I_M = \lambda_M B, I_A = (1 - \lambda_M)B$$

where $L^l_M(L^l_A)$ the lobbying effort by the coalition [10].

Before the discussion of the lobbying equilibrium, it is useful for us to provide a background for analyzing the resource loss from these lobbying activities by considering the 'first best' resource allocation in this economy. We define the 'first best' solution as the allocation such that national income is maximized. Given the endowments of labor, capital and land , and the international price, government can find the 'first best' solution by choosing the total amount of public intermediate good (B), labor employment patterns (L_M and L_A) and the allocation of public intermediate good (λ_M) among sectors to maximize the following objective function:

[8] A different simplifying assumption has been made by Findlay and Wellisz (1988): they consider the public good as "institutions", " law and order", and they assume this particular public good is produced only by labor. In this analysis, we consider those capital-intensive public intermediate good which are important to explain the diversity in sectoral employment patterns among different countries, e.g. infrastructure and public research activities.

[9] It may be argued that a better specification would be to let the total amount of public intermediate good also be affected by lobbying activities. However, such a specification would complicate the analysis a lot. Thus, we simply assume the total amount of public intermediate is exogenous, through we shall study its relation with the lobbying equilibrium in the analysis.

[10] For sake of simplicity, we simply assume there are two coalitions representing capitalists and landlords respectively.

$$P^{*}F(L_M, \lambda_M B, \bar{K} - B) + G(\bar{L} - L_M, (1 - \lambda_M)B, \bar{D})$$

Suppose $(B^{*}, \lambda^{*}, L_M^{*})$ is the optimal solution. Then the first order conditions imply:

$$P^{*}[\lambda_M^{*} F_{I_M}(*) - F_K(*)] + (1 - \lambda_M^{*})G_{I_A}(*) = 0 \tag{3.1}$$

$$P^{*}F_{I_M}(*) - G_{I_A}(*) = 0 \tag{3.2}$$

$$P^{*}F_L(*) - G_L(*) = 0 \tag{3.3}$$

where $F_j(*)$ (or $G_j(*)$) represents the derivative of $F(\cdot)$ (or $G(\cdot)$) with respect to j evaluated at the optimum.

Equation (3.1) represents the allocation of capital as a direct production input in the manufacturing sector, and as public intermediate inputs in the agricultural and manufacturing sectors. One more unit of public intermediate good being supplied to either one sector represents one less unit of capital being used in the direct production of the manufactured goods. Equation (3.2) represents the allocation of public intermediate goods between the manufacturing sector and the agricultural sector. The value of marginal products of the public intermediate good in the production of manufactured goods and in the production of agricultural goods are equalized at the optimum, since one unit of public intermediate good can be used either in the production of manufactured goods or in the production of agricultural goods. Equation (3.3) is the standard optimal condition of the allocation of labor among sectors in which, the value of marginal products of labor in different sectors are equalized. Following this characterization of the 'first best' allocation, we shall now discuss the resource allocation in the presence of lobbying.

3.3 Lobbying Equilibrium

In this section, we consider the resource allocation when the budget for public intermediate good is allocated among sectors according to the lobbying inputs by the two interest groups. For the sake of simplicity, we assume the following form for the allocation rule :

$$\lambda_M(L_M^l, L_A^l) = \frac{f(L_M^l)}{f(L_M^l) + g(L_A^l)};$$

where $f(L_M^l)$ is the effective lobbying effort by capitalists and $g(L_A^l)$ is the effective lobbying effort by landlords.

We further specify the allocation rule by postulating that 1) $f(L_M^l) = \theta_M + L_M^l$ and 2) $g(L_A^l) = \theta_A + L_A^l$. We assume $\theta_M + \theta_A = 1$ so that $\lambda_M(0,0) = \theta_M$ [11] which represents the allocation policy in the absence of lobbying activity [12] .

From the above specification, we can derive the following properties [13]:

$$\frac{\partial\lambda_M}{\partial L_M^l}, \frac{\partial^2\lambda_M}{\partial {L_A^l}^2} > 0; \quad \frac{\partial\lambda_M}{\partial L_A^l}, \frac{\partial^2\lambda_M}{\partial {L_M^l}^2} < 0; \quad \frac{\partial^2\lambda_M}{\partial L_M^l \partial L_A^l} \gtreqless 0$$

According to our lobbying technology, additional lobbying effort by capitalists (landlords) increases the allocation of public intermediate good to the manufacturing (agricultural) sector at a decreasing rate, given the lobbying effort by the landlords (capitalists).

We are looking for a Nash-Full Employment-Lobbying (NFL) equilibrium (W^*, L_M^*, L_A^*, L_M^{l*}, L_A^{l*}) such that

[11] As discussed by Findlay and Wellisz (1984), there is an asymmetry in the lobbying cost among capitalists and landlords in the developing countries. "$\cdots$ In developing countries industry tends to be highly concentrated, while agriculture, where there are no latifundia, is often very dispersed, giving a cost edge to the organization of capitalists' lobbies. The geographic dispersion of agricultural holdings and the fact that, by and large, capitalists are better educated, hence more aware of the importance of trade policies than the landlords, also contribute to the higher cost of organizing the latter compared with the former.$\cdots$". We capture this feature ("policy bias"), by postulating that $\theta_M \geq 0.5$.

[12] This type of representation of the lobbying (or rent-seeking) technology is widely used in the public choice literature. See, for example, Buchanan, Tollison and Tullock (1980).

[13] One can show $\frac{\partial^2\lambda_M}{\partial L_M^l \partial L_A^l} \gtreqless 0 \;\; iff \;\; f(\cdot) \gtreqless g(\cdot)$.

Since there is no widely accepted theory or evidence relating to lobbying activities in either LDCs or developed countries, there is no information to restrict the sign of this cross derivative. According to our formulation, λ_M^{12} would be positive (negative) if lobbying efforts by capitalists (landlords) are more effective (given the amount of labor used) than those by landlords (capitalists). We could impose restriction that λ_M^{12} is always negative (it seems to be a more reasonable assumption which implies that more lobbying activity by landlords would decrease capitalists' marginal product in lobbying activity) . However, this assumption would restrict the range of equilibrium outcomes.

1) For i, j = M, A, L_i^{l*} and L_i^* solve the maximization problem of interest group i given L_j^{l*} and L_j^* and the equilibrium wage rate W^*.

2) Full employment of labor: $L_M^* + L_A^* + L_M^{l*} + L_A^{l*} = \bar{L}$

3) Full employment of capital and land: $K_M + B = \bar{K}; D_A = \bar{D}$

where $K_M(D_A)$ represents the capital (land) used for the direct production of manufactured (agricultural) goods.

First, we discuss the maximization behaviour of the interest group representing capitalists. We simply assume there is only one representative firm. Given L_A^l and the wage rate (W^*) , this representative firm in the manufacturing sector has to solve the following maximization problem by choosing L_M^l and L_M:

$$Max \quad P^* F(L_M, I_M, K_M) - W^*(L_M + L_M^l)$$

The first order conditions are

$$P^* F_L = W^*, \tag{3.4}$$

and

$$P^* F_{I_M} \frac{\partial I_M}{\partial L_M^l} = W^*. \tag{3.5}$$

Equations (3.4) and (3.5) represent the marginal conditions governing the manufacturing sector's employment decision for a given lobbying effort by the landlords and a given wage rate: They can b interpreted as saying that the marginal product of labor in both production and lobbying have to equal the (given) wage rate.

From those first order conditions, one can see that L_M and L_M^l may be interpreted as imperfectly substitutable inputs in the production of final goods, since more labor input to lobbying can get more public intermediate good which is a production substitute for labor. From our formulation, the marginal productivity of L_M (L_M^l) will be higher if there is more employment in L_M^l (L_M) [14]. On the other

[14] According to our specification, F_{LI_M} is positive.

hand, the marginal costs of hiring an additional unit of L_M or L^l_M are equal to each other since there is only one kind of labor. Hence, their marginal products should be equalized in the production equilibrium.

From the definitions of $F(\cdot)$, I_M, and λ_M, we can solve equations (3.4) and (3.5) so as to represent the employment of labor in the production of manufactured goods as a function of the lobbying efforts by both landlords and capitalists:

$$L_M(L^l_M, L^l_A) = \frac{\alpha_M f(L^l_M)(f(L^l_M) + g(L^l_A))}{\delta_M g(L^l_A)} \tag{3.6}$$

From equation (3.6), we can easily derive: $\frac{\partial L_M}{\partial L^l_M} > 0, \frac{\partial L_M}{\partial L^l_A} < 0$. These can be interpretated as follows. First, more labor is employed in the production of manufactured goods if more labor is employed in lobbying by the capitalists, for a given lobbying effort by the landlords. This positive relation is due to the positive effect of the availability of the public intermediate good on the marginal productivity of labor in the production process. That is, in the presence of a larger lobbying effort by the capitalists, more of the public intermediate good will be allocated to the manufacturing sector, for a given lobbying effort by the landlords, which increases the marginal product of labor in the production of manufactured goods. Second, less labor is employed in the production of manufactured goods if there is more lobbying effort by the landlords, for a given lobbying effort by the capitalists. In this case, less of the public intermediate good is allocated to the manufacturing sector, which decreases the marginal productivity of labor in the production process.

Substituting equation (3.6) into equation (3.5), we can represent the marginal product of labor in lobbying by capitalists , W_M, as a function of L^l_M and L^l_A alone. In equilibrium, this marginal product has to be equal to the wage rate of labor. [15]

$$W_M(L^l_M, L^l_A) = W^* \tag{3.7}$$

[15]The algebraic expression is shown in the appendix.

Given W^* and L_A^l, one can solve equation (3.7) to determine the lobbying effort by the capitalists [16]. One can also show that a higher wage rate has a negative effect on the employment of labor by the capitalists in the lobbying process. However, the effect of L_A^l on L_M^l is ambiguous. There are two effects by L_A^l on the "marginal product" of L_M^l [17]. First, the marginal product of the lobbying activities by capitalists depends on the level of lobbying efforts by landlords through the function $\lambda_M(L_M^l, L_A^l)$. We call this the direct strategic effect. However, there is not enough empirical or theoretical support for us to restrict the sign of this cross effect. Hence, an increase in the lobbying efforts by landlords may or may not increase the marginal product of the lobbying efforts by capitalists. Second, an increase in the lobbying intensity by landlords would decrease the allocation of public intermediate good to the manufacturing sector for a given lobbying intensity by capitalists. This has two effects. First, it would decrease the employment of labor in the direct production of manufactured goods as the marginal product of labor in the direct production decreases. This effect would further decrease the employment of labor for lobbying since it reduces the marginal product of lobbying by capitalists. However, there is another effect in the opposite direction. With a smaller amount of public intermediate good, in manufacturing, the marginal product of lobbying by capitalists would increase, as we assume a Cobb-Douglas production function so that F_{I_M} increases, for given L_M. We call the net effect of these two forces the indirect strategic effect and the direction of this effect is also uncertain. From equation (3.7), we know that overall would be positive if L_A^l is significantly smaller than L_M^l. On the other hand, it would be negative if L_A^l is significantly higher than L_M^l [18].

We turn next to the optimizing behavior of the coalition of landlords. By reasoning similar to above, we can derive the following expressions from the first order

[16]The lobbying technology, and the Cobb-Douglas form of the production, imply that the second order condition for a maximum is satisfied.

[17]There are effects on both I_M and L_M

[18]One can show that the effect is positive (negative) if $(1-\alpha_M)f(\cdot) - \delta_M g(\cdot) > (<) \ 0$.

conditions for the maximization problem of this coalition. First, we can represent the employment of labor for the production of agricultural goods as a function of lobbying efforts by landlords and capitalists:

$$L_A = \frac{\alpha_A g(L_A^l)(f(L_M^l) + g(L_A^l))}{\delta_A f(L_M^l)} \tag{3.8}$$

From equation (3.8), we can derive the relation among the wage rate , the lobbying efforts by capitalists and the lobbying efforts by landlords [19]:

$$W_A(L_M^l, L_A^l) = W^* \tag{3.9}$$

We now turn to the description of the conditions of general equilibrium. Two conditions must hold in general equilibrium: First, the wage rate offered by capitalists must equal the wage rate offered by the landlords.

From equations (3.7) and (3.9), we can define

$$EW(L_M^l, L_A^l) = W_M(L_M^l, L_A^l) - W_A(L_M^l, L_A^l) \tag{3.10}$$

corresponding to first order conditions. Second, since equilibrium employment of labor in the direct production process in each sector can be represented as a function of the lobbying efforts in each sector, we can define the following function to decribe the full employment of labor:

$$\begin{aligned} FE(L_M^l, L_A^l) &= \frac{\alpha_M f(L_M^l)(f(L_M^l) + g(L_A^l))}{\delta_M g(L_A^l)} + \frac{\alpha_A g(L_A^l)(f(L_M^l) + g(L_A^l))}{\delta_A f(L_M^l)} \\ &+ L_M^l + L_A^l - \bar{L} \end{aligned}$$

where we have used equations (3.6) and (3.8).

General equilibrium of this small open economy is described by a set of (L_M^{l*}, L_A^{l*}) such that the following conditions are satisfied [20]:

[19]By reasoning entirely analogous to that used in deriving the above footnote, one can show that an increase in L_M^l increases (decreases) L_A^l if $(1 - \alpha_A)g(\cdot) - \delta_A f(\cdot) > (<)\ 0$.

[20]Our assumption on the production function (Cobb-Douglas) simplifies the general equilibrium conditions. We assume the full employment conditions for capital and land are satisfied.

$$EW(L_M^{l*}, L_A^{l*}) = FE(L_M^{l*}, L_A^{l*}) = 0$$

Before we study the comparative statics of the lobbying equilibrium, it is useful for us to know the properties of the equilibrium conditions: $EW(L_M^{l*}, L_A^{l*}) = 0$ and $FE(L_M^{l*}, L_A^{l*}) = 0$.

1) $EW(L_M^l, L_A^l) = 0$

This function relates L_M^l and L_A^l such that wage rates across sectors are equalized in equilibrium. We shall study the slope of this function . As shown in the appendix, by using the implicit function theorem, we can derive the slope from the following derivative:

$$\left.\frac{\partial EW}{\partial L_M^l}\right|_{EW=0} < 0$$

Given L_A^l and equation (3.7), an increase in L_M^l decreases the marginal product of labour in manufacturing, whether the labour is used in lobbying effort or in production. This decreases the wage rate offered by the capitalists. On the other hand, an increase in L_M^l has an ambiguous effect on the marginal productivity of labour used in agricultural production or in the lobbying effort by the landlords, in the presence of both the direct and indirect strategic effects, as described before. However, we show in the appendix that an increases in L_M^l has a negative effect on EW, given L_A^l.

Similarly, from $EW(\cdot,\cdot) = 0$ in equilibrium and the assumption that $(C1)$: $\alpha_A + \delta_M < 1$ [21] , we can determine the sign of the derivative:

$$\left.\frac{\partial EW}{\partial L_A^l}\right|_{EW=0} > 0$$

Given L_M^l, an increase in L_A^l decreases the value of marginal product of labour in agriculture, whether used in production or in the lobbying effort, which decreases

[21] We will retain this assumption in the following analysis. This assumption implies that the share of either capital or land in final production is sufficiently large. As we show in the appendix, we do not need a similar condition to assign a sign to $\frac{\partial EW}{\partial L_l^M}$ since $\alpha_M + \delta_A < 1$.

the wage offered by the landlords. On the other hand, an increase in L_A^l has an ambiguous effect on the marginal productivity of manufacturing labour in the presence of both the direct and indirect strategic effects. The net effect depends on the relative size of the lobbying efforts by the different groups, and also on the relative size of the capital share $(1-\alpha_M-\delta_M)$ and the public intermediate good's share (δ_M) in the production of manufactured goods. However, we show in the appendix that an increase in L_A^l has a positive effect on EW, given L_M^l, if the public intermediate good's share is sufficiently small. Assuming this is the case, we can determine the slope of $EW(\cdot,\cdot)=0$:

$$\left.\frac{dL_A^l}{dL_M^l}\right|_{EW(\cdot,\cdot)=0} > 0$$

A possible locus of $EW(L_M^l, L_A^l)=0$ is shown on Fig. 1. We use EW to denote this locus. From the definition of $EW(L_M^l, L_A^l)=0$, one can show that the intercept may be on the $g(\cdot)$-axis or $f(\cdot)$-axis. [22]

2) $FE(L_M^l, L_A^l)=0$

$FE(\cdot,\cdot)=0$ is a locus in L_M^l, L_A^l space such that there is full employment in the labor market. We need the following two derivatives before further analysis.

$$\frac{\partial FE}{\partial L_M^l} = 1 + \frac{2\alpha_M f(L_M^l)}{\delta_M g(L_A^l)} + \frac{\alpha_M}{\delta_M} - \frac{\alpha_A g(L_A^l)^2}{\delta_A f(L_M^l)^2} \quad \substack{\geq \\ <} \quad 0 \tag{3.11}$$

$$\frac{\partial FE}{\partial L_A^l} = 1 + \frac{2\alpha_A g(L_A^l)}{\delta_A f(L_M^l)} + \frac{\alpha_A}{\delta_A} - \frac{\alpha_M f(L_M^l)^2}{\delta_M g(L_A^l)^2} \quad \substack{\geq \\ <} \quad 0 \tag{3.12}$$

[22] One can show that the intercept will be on the $g(\cdot)$-axis ($f(\cdot)$-axis) if

$$P^* B^{\delta_M} \theta_M^{\alpha_A+\alpha_M+\delta_M-2} K_M^{1-\alpha_M-\delta_M} \quad < \quad (>) \quad \theta_A^{\alpha_A+\alpha_M+\delta_M-2} B^{\delta_A} \bar{D}^{1-\alpha_A-\delta_A}.$$

On the other hand, one can show that

$$\frac{d\hat{L}_A^l}{dK_M} \quad < \quad 0; \frac{d\hat{L}_A^l}{dD_A} \quad > \quad 0$$

where $\hat{L}_A^l$ satisfies $EW(0, \hat{L}_A^l) = 0$.

Hence, the sign of $\left.\frac{dL_A^l}{dL_M^l}\right|_{FE=0}$ is ambiguous in general. We only discuss the effects on FE when there is an increase in L_M^l. Similar reasoning can be applied to an increase in L_A^l.

The ambiguity arises because an increase in L_M^l has two opposite effects. One is to increase the employment of labor for the production of manufactured goods, because the marginal product of labor is raised when I_M is increased. We call this the *positive employment effect.* The other effect is to decrease the employment of labor for the production of agricultural goods. We call this the *negative employment effect.* Although we cannot determine the sign in general, it is possible to find a range of (L_M^l, L_A^l) such that the sign of the derivative can be determined. From equations (3.6) and (3.8), we know that the negative employment effect of L_M^l is higher for a lower value of the ratio $g(L_A^l)$ to $f(L_M^l)$. If the ratio $g(L_A^l)$ to $f(L_M^l)$ is low, the employment of labor for the direct production of manufactured goods is high, which leads to a large negative employment effect as a result of an increase in the lobbying intensity by landlords.

To simplify notation, we define $x = g(L_A^l)/f(L_M^l)$ in the following analysis. From lemma A.3.1 and lemma A.3.2 in the appendix, we can derive the following lemma:

Lemma 3.1 If (C2) : $\alpha_A < \delta_A$ and (C3) : $\alpha_M < \delta_M$ are satisfied, [23] there exists (x_L, x_H) $(x = g(\cdot)/f(\cdot))$ [24] such that

1) $x_L \; < \; 1 \; < \; x_H$

2) $\left.\frac{dL_A^l}{dL_M^l}\right|_{FE=0} \; > \; 0, \;\; \forall x \in (0, x_L);$

3) $\left.\frac{dL_A^l}{dL_M^l}\right|_{FE=0} \; < \; 0, \;\; \forall x \in (x_L, x_H)$ and

4) $\left.\frac{dL_A^l}{dL_M^l}\right|_{FE=0} \; > \; 0, \;\; \forall x \in (x_H, \infty).$

[23] C3 (C2) implies that the share of public intermediate goods is larger than that of labor in the direct production of manufactured (agricultural) goods. We will retain C2 and C3 in the further analysis.

[24] We also discuss how the parameters in the model affect the value of x_L and x_H in the appendix.

Proof: The results follow immediately from lemma A.3.1 and lemma A.3.2 . **Q.E.D.**

A possible locus for $FE(L_M^l, L_A^l) = 0$ is shown on Fig. 2 . We use FE to denote this locus.

Before we go to comparative statics, we need to determine the sign of the following expression:

$$J = \frac{\partial EW}{\partial L_M^l}\frac{\partial FE}{\partial L_A^l} - \frac{\partial EW}{\partial L_A^l}\frac{\partial FE}{\partial L_M^l}\Big|_{EW=FE=0}$$

In the appendix, it is shown that $J < 0$, provided assumption C1 is satisfied. In the following analysis, we simply assume a NFL equilibrium exists. The preceding result shows that, provided C1 holds, the slope of the $EW = 0$ must be greater than that of the $FE = 0$ at the intersection point. Three possibilities of equilibrium are shown on Fig. 3 - 5.

In Fig. 3, $x^* > x_H$ [25] . As we discussed previously, this would be the case if the economy has a sufficienly large amount of land relative to the amount of capital. In Fig. 5, there are multiple equilibria. One equilibrium has an x^* which is less than x_L. This would be the case if the economy has a sufficiently large stock of capital relative to the amount of land. If we are considering an economy which is close to symmetry between the two sectors, the case shown on Fig.4 would be the likely outcome.

We will now turn to a study of how government policies affect the lobbying equilibrium . It will be shown that most results depend on the equilibrium ratio of $g(L_A^{l*})$ to $f(L_M^{l*})$. We shall further discuss how those results relate to the position of $EW(L_M^l, L_A^l) = 0$ and hence the endowment of the economy.

---

[25] $x^* = \dfrac{g(L_A^{l*})}{f(L_M^{l*})}$.

One can show that $\dfrac{dx^*}{dK_M} < 0, \dfrac{dx^*}{dD_A} > 0$

3.4 Policies and Allocation of Public Intermediate Good

In this section, we study two types of government policies. One is industrial or trade policy [26] which affects the relative producer price of the manufactured goods. The other is a policy concerning the amount of government funds allocated to the supply of public intermediate good, that is, an increase in the parameter B in the model.

First, the effect of an increase in the relative price of the manufactured goods will be discussed . The policies that would give rise to such a change could be a direct production subsidy (tax) on the manufactured (agricultural) good, or a tariff (export subsidy) on the manufactured (agricultural) good if this country imports the manufactured good.

As shown on Fig. 6, when P rises, the EW line shifts down. There are now three possibilities depending on the location of the initial equilibrium.

Proposition 3.1 *A small increase in the relative producer price of the manufactured goods necessarily increases the labor employment in the production of manufactured goods and the allocation of public intermediate good to the manufacturing sector. However, it decreases the allocation of public intermediate good to the agricultural sector and the labor employment in the production of agricultural goods. It also*

1) increases the lobbying effort by landlords and capitalists if the ratio of capital for the production of manufactured goods to land, $(\bar{K} - B/\bar{D})$, is sufficiently low (or $\infty > x^* > x_H$).

2) decreases the lobbying effort by landlords and capitalists if the ratio of capital for the production of manufactured goods to land, $(\bar{K} - B/\bar{D})$, is sufficiently high (or $x^* < x_L$).

[26] We restrict our discussion to those tariffs or direct productio~ tax (or subsidy).

3) decreases the lobbying effort by landlords and increases the lobbying effort by capitalists, otherwise.

Proof: From the definition of λ_M, it is shown in the appendix that:

$$\frac{d\lambda_M}{dP^*} > 0$$

It is also shown in the appendix that the employment of labor in the production of manufactured (agricultural) goods increases (decreases):

$$\frac{dL_M^*}{dP^*} > 0$$

$$\frac{dL_A^*}{dP^*} < 0$$

From lemma A.1 and lemma A.2, we can derive the following results:

1)$\frac{dL_M^{l*}}{dP^*}, \frac{dL_A^{l*}}{dP^*} > 0$ if $\infty > x^* > x_H$.

2)$\frac{dL_M^{l*}}{dP^*} > 0, \frac{dL_A^{l*}}{dP^*} < 0$ if $x_H > x^* > x_L$.

3)$\frac{dL_M^{l*}}{dP^*}, \frac{dL_A^{l*}}{dP^*} < 0$ if $x_L > x^* > 0$.

Since $\frac{dx^*}{dK_M} < 0, \frac{dx^*}{d\bar{D}} > 0$, case 1 (2) is likely the case if the ratio of capital for the production of manufactured goods to land is low (high). Q.E.D.

Next we provide an interpretation of these comparative statics results concerning the effects of a small increase in the producer price of manufactured goods. First, suppose we keep the wage rate constant. An increase in the producer price of manufactured goods, other things being constant, increases the marginal product of labor in both lobbying and production activities by capitalists (see equations (3.4) and (3.5)). Hence, both the lobbying intensity of capitalists and the labor employment in the production of manufactured goods are increased as a result of the first round effect . However, there are second round effects since the first round effect affects landlords' decision. The second round effect is the strategic effect discussed in the earlier analysis. There are both direct and indirect effects. First, the direct strategic effect leads to a decrease (an increase) in the lobbying effort by the landlords, since an increase in the lobbying effort by the capitalists decreases (increases) the marginal product of lobbying effort by capitalists if $x^* > 1$ ($x^* < 1$). Second, there is also an indirect strategic effect, due to the fact that an increase in the lobbying effort of capitalists decreases the allocation of public intermediate good to the agricultural sector. However, this has an uncertain effect on the " marginal product " of lobbying activity by landlords. Since we assume a Cobb-Douglas production function, there is a direct positive effect on the marginal product of lobbying by landlords because of the decrease in the availability of the public intermediate good in the agricultural sector. On the other hand, it also decreases the labor employment in the direct production of agricultural goods and hence decreases the marginal product of lobbying by landlords (since $G_{I_A L}$ is positive). The determinant of the direction of the net strategic effect is discussed in an earlier footnote. It can be shown that the net effect of an increase in P^* on the lobbying effort by landlords is positive (negative) if the initial x^* is high (low).

The preceding discussion is based on the assumption of a constant wage rate. We next consider the effect of a change on the equilibrium wage rate, and then the ultimate labor allocation.

The increase in the labor demanded for the capitalists' lobbying effort and for the production of manufactured goods increases the total demand for labor. This is what we called the positive employment effect. This effect will tend to push up the wage rate. On the other hand, the negative employment effect decreases the demand for labor in the production of agricultural goods, which decreases the wage rate. As we have shown in the preceding analysis, the positive effect will dominate if the value of x is low. Hence, in this case, we would expect an increase in the wage rate since the demand for labor increases, which tends to decrease the demand for lobbying effort by landlords. On the other hand, we would expect the negative effect to dominate if the value of x is high. In this case, we would expect the wage rate to decrease since the demand for labor decreases, which will increase the lobbying effort by the landlords.

As shown in proposition 3.1, an increase in the relative producer price of manufactured goods necessarily increases (decreases) the allocation of public intermediate good to the manufacturing (agricultural) sector and increases (decreases) the labor employment for the direct production of manufactured (agricultural) goods. If the ratio of capital employed in the manufacturing sector to land is sufficiently high ($x^* < x_L$), we would expect there to be an increase in the lobbying effort by capitalists and a decrease [27] in the lobbying effort by landlords (the strategic effect), for a given initial wage rate. In this low x^* initial equilibrium, we expect there to be a positive effect on the wage rate and then we have shown that lobbying efforts by both capitalists and landlords are decreased. On the other hand, if the ratio of capital employed in the manufacturing sector to land is sufficiently low ($x^* > x_H$), we would expect there to be an increase in the lobbying effort by capitalists and landlords (the strategic effect), for a given initial wage rate. However, in this high initial x^* equilibrium, we may also expect a decrease in the wage rate, and then we have shown that the lobbying efforts by both capitalists and landlords are increased. If $x_H < x^* < x_L$, the net result would be an increase in the lobbying effort by capitalists and a decrease in the lobbying effort by landlords .

Finally, we consider the effect of a change in the total budget for supplying public intermediate good on the lobbying equilibrium. As shown on Fig. 7, the EW line may shift up or down depending on the values of the parameters in our model.

Proposition 3.2 *If*

$$\frac{\delta_M - \delta_A}{1 - \alpha_M - \delta_A} > \frac{B}{K}$$

[27] It is necessarily true if we assume $x_L < \delta_A / 1 - \alpha_A$.

small increase in the total budget B for supplying public intermediate goods necessarily increases the labor employment for the production of manufactured goods and the allocation of the public intermediate good to the manufacturing sector. However, it decreases the allocation of public intermediate good to the agricultural sector and the labor employment for the production of agricultural goods. It also

1) increases the lobbying effort by landlords and capitalists if the ratio of capital to land is sufficiently low (or $\infty > x^* > x_H$*).*

2) decreases the lobbying effort by landlords and capitalists if the ratio of capital to land is sufficiently high (or $x_L < x^* < 0$*).*

3) decreases the lobbying effort by landlords and increases the lobbying effort by capitalists, otherwise.

An analogous result holds if the inequality holds in other direction.

Proof: The proof is similar to that for proposition 3.1.

An increase in the total supply of public intermediate good, other things being constant, implies three first round effects on the lobbying equilibrium. First, the supply of capital stock to the production of manufactured goods decreases, since public intermediate good are produced by capital. This effect tends to reduce the marginal productivity of both labor for the production of manufactured goods and labor for lobbying. Second, an increase in B increases the supply of public intermediate good to both sectors, if lobbying intensities remains unchanged. This increases the marginal productivity of labor in production. Moreover, the increase in B also increases the marginal product of labor engaged in lobbying in both sectors. Hence, the net effect depends on the relative magnitude of the above effects. From our formulation, the magnitude of the first effect depends on the amount of public intermediate good relative to the total capital stock. The larger the relative amount of the public intermediate good, the larger will be the first effect, which tends to decrease the lobbying intensity by the capitalists. The second effect depend on the share parameters in the production functions. One can find that the larger the magnitude of the share parameter in the production of manufactured (agricultural) goods, that is δ_M (δ_A), the larger will be the second effect which tends to increase the lobbying intensity by the capitalists (landlords). As in the case considered in proposition 1, there are also <u>second round effects</u>. These are similar, and will not be discussed.

3.5 Concluding Remarks

This paper provides a simple model to study the relationship among lobbying, the allocation of public intermediate good and resource allocation in a general equilibrium framework. In the rest of this section, we shall briefly discuss the welfare-implications of the lobbying equilibrium and then conclude this section by a discussion on possible extensions.

The general equilibrium of this small open economy with lobbying is described by equations (3.7), (3.9) and the full employment condition. Comparing these conditions with the first order conditions of the 'first best' problem, one can find the following implications. First, lobbying activity represents a resource loss since labor has a positive productivity in the production of final goods. Second, there may be a distortion in the allocation of the remaining labor.

One can understand these effects by considering a symmetric model in which $\alpha_M = \alpha_A$, $\delta_M = \delta_A$, $\theta_M = 0.5$ and $P^* = 1$. We further assume that the government chooses the 'first best' total amount of public intermediate good, B^*. In this case, the outcome of the lobbying game will be $\lambda_M = \lambda_A = 0.5$, which is equal to the ratio in the 'first best' allocation of public intermediate good. Therefore, the relative labor employment for direct production would be the same as in the 'first best' allocation if there were no loss of labor resources because of lobbying .

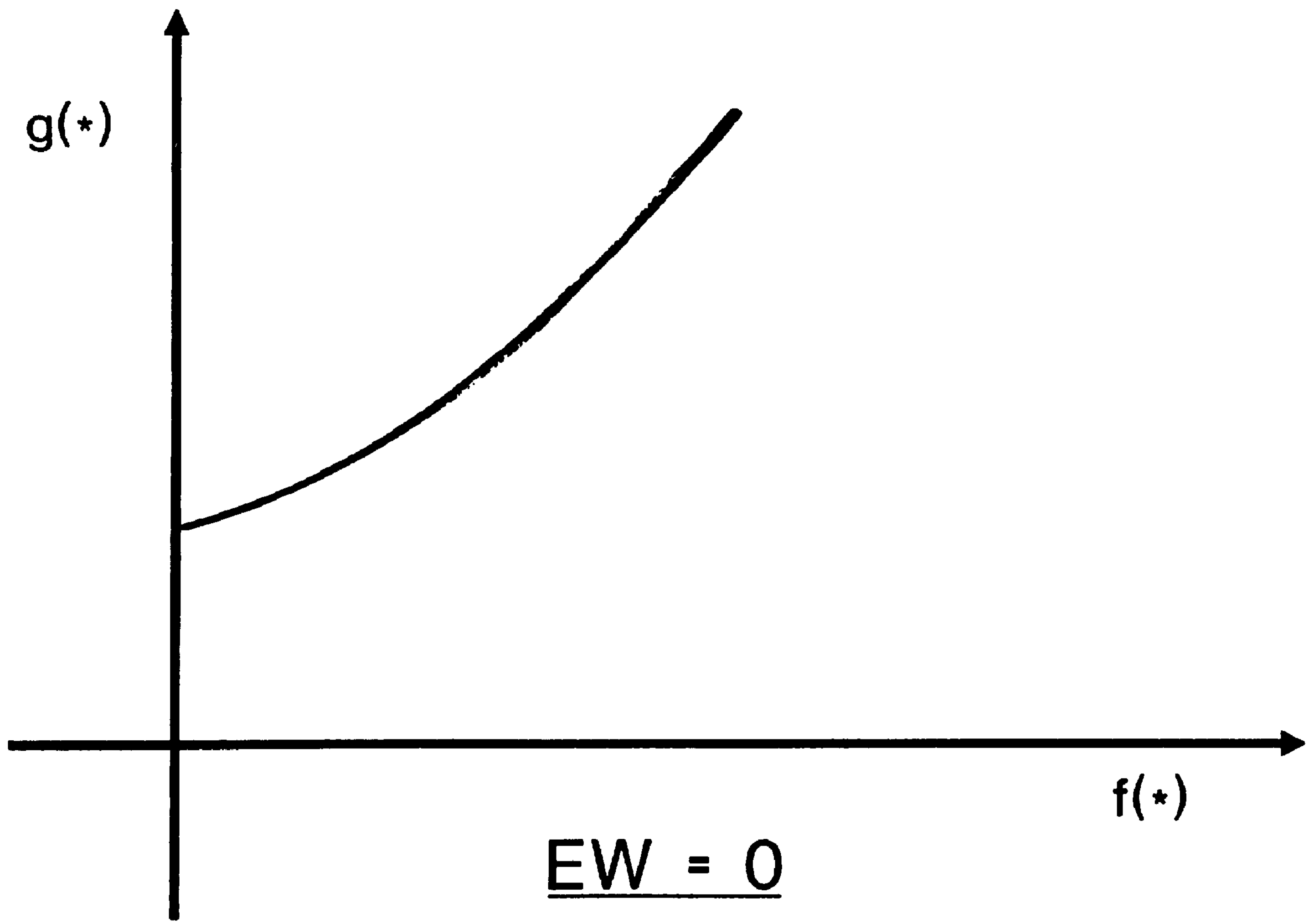
However, as the model is specified, the lobbying process does use up some of the labor resource. This will increase the equilibrium wage rate, and decrease the labor employment in direct production. Hence, the lobbying equilibrium differs from the 'first best' solution even in a symmetric model with a 'first best' relative allocation of public intermediate good. If we relax the symmetry assumption, the amount of labor in direct production in each sector will be affected not only by the loss of labor because of lobbying, but also by the allocation of the public intermediate good as the outcome of the lobbying. This is because the allocation of the public intermediate good affects the productivity of labor in the direct production process. As a result of the lobbying, the national income is lower than it would be in which the labour remaining (after taking account of the labour wasted in lobbying) were optimally allocated.

If we accept the fact that, in a democratic society, policy is affected not only by lobbying, but also by the number of votes the government receives in elections, one possible interesting extension would be to study the resource allocation when the allocation rule (of the public intermediate good) depends on the relative amount of labor employment in direct production in the two sectors, instead of, on the lobbying effort. For example, the policy rule could be specified as ($\lambda_M = f(L_M)/[f(L_M) + g(L_A)]$).

Another extension would be to analyze the dynamic effects of different allocation rules. As we have discussed in the introduction that the provision of public intermediate good among different sectors affects the process of industrialization and hence the rate of economic growth [28]. However, the present model is a static one

[28] There are a number of work on the relation of political activities and economic growth. Adelman and Morris (1967) provide the first empirical study on the relation among political factors and economic growth, . They find that there is no obvious relation across countries between political factors and the level of development. Olson (1982) studies the effect of interest group activities on economic growth and inflation and concludes that " $\cdots$ distributional coalitions slow down a society's capacity to adopt new technologies and to reallocate resource in response to changing conditions and thereby reduce the rate of economic growth.$\cdots$".

and therefore cannot be used to study how the rent-seeking activity relates to the dynamic process of economic development. One possible extension to do so , would be the specificationof a two-period model in which capitalists and landlords lobby in the first period to affect the allocation of the public budget for sector-specific research, which will affect the sector's productivity in the second period. If we introduce an investment decision in the first period, we can also study the relation between capital accumulation and rent-seeking activities. In this framework, rent-seeking would not only lead to a static distortion but also to a dynamic distortion which would cause a lower growth rate.



EW = 0

Fig. 1

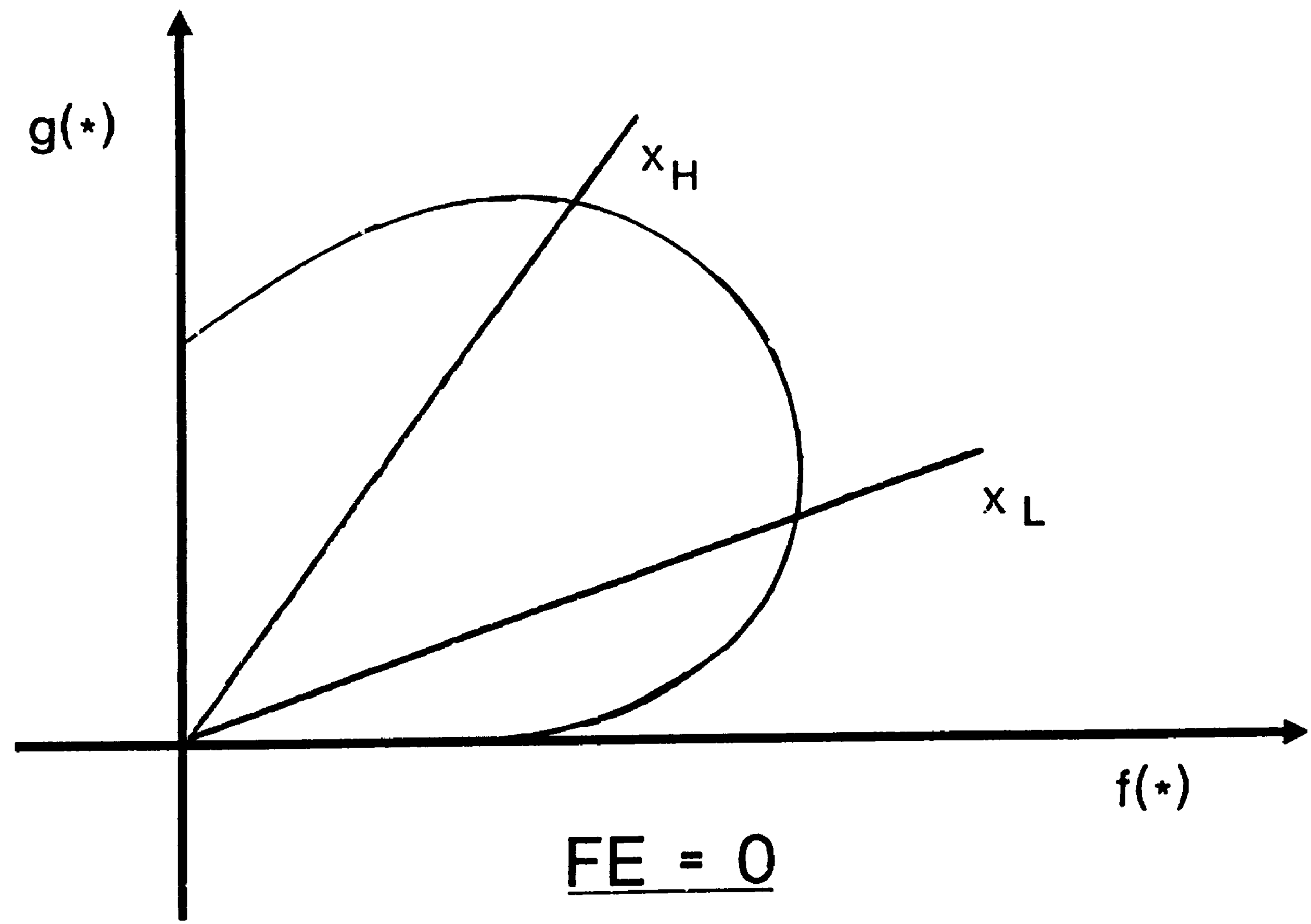
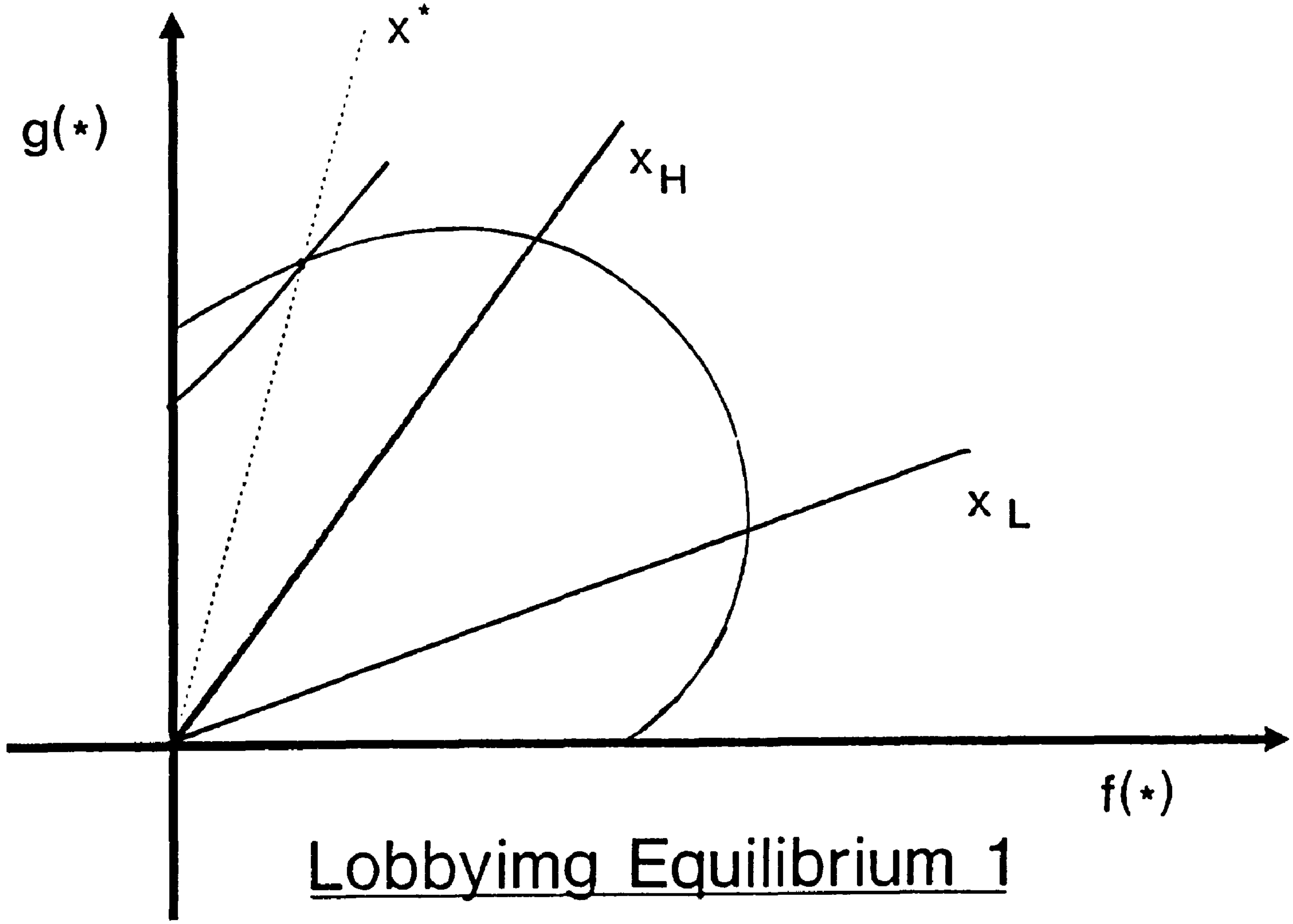
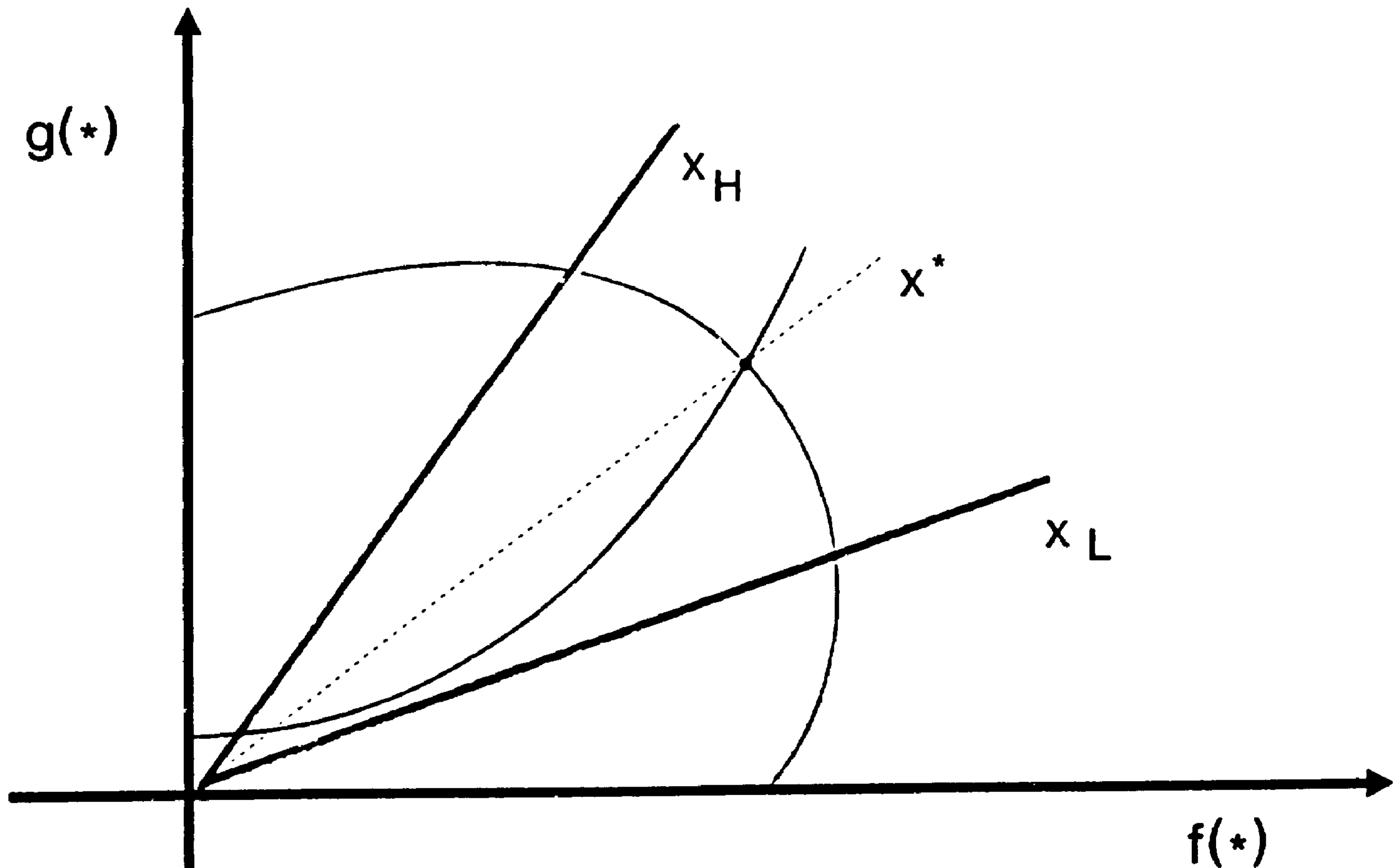


Fig. 2



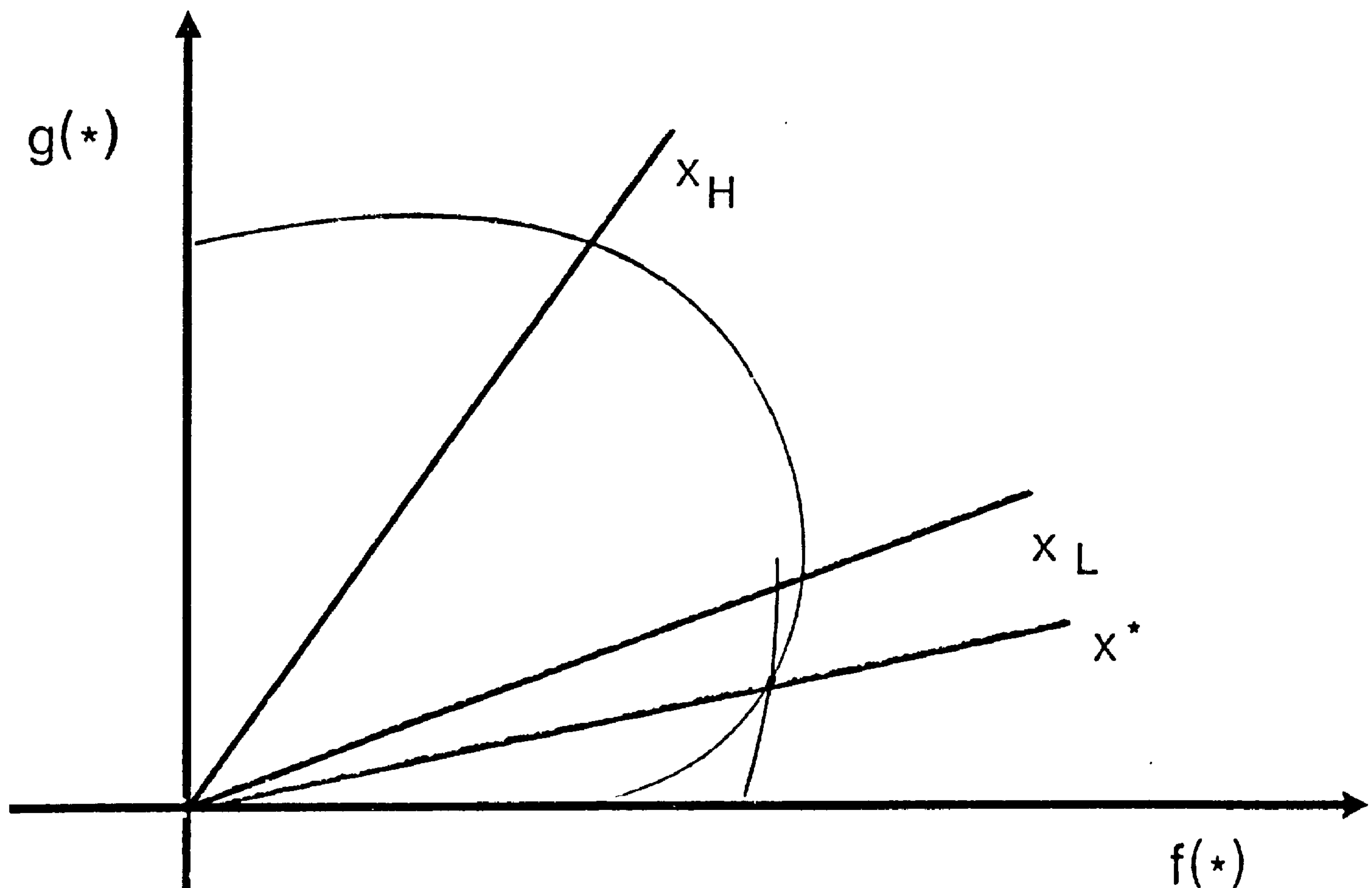
Lobbyimg Equilibrium 1

Fig. 3



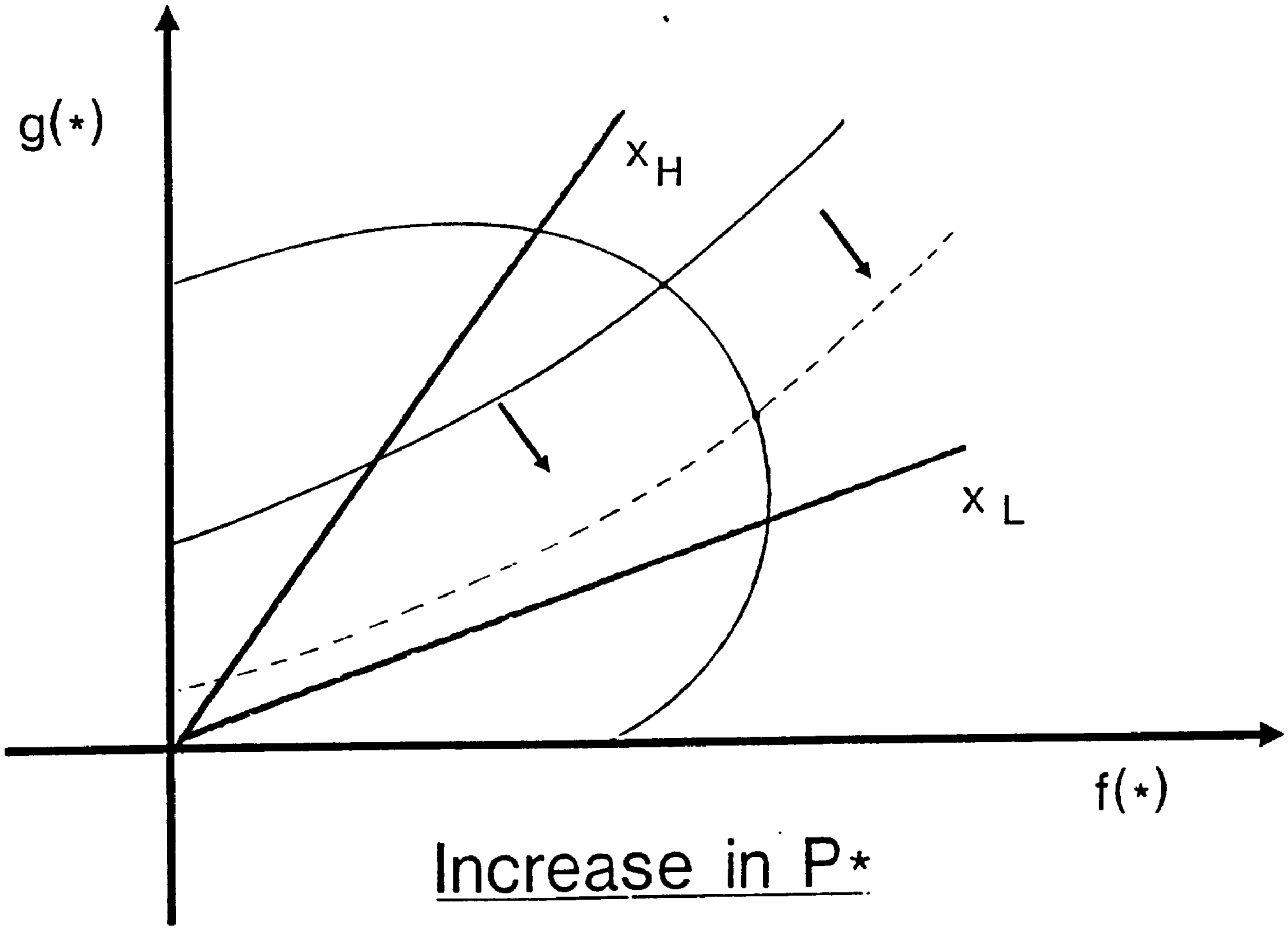
Lobbying Equilibrium 2

Fig. 4



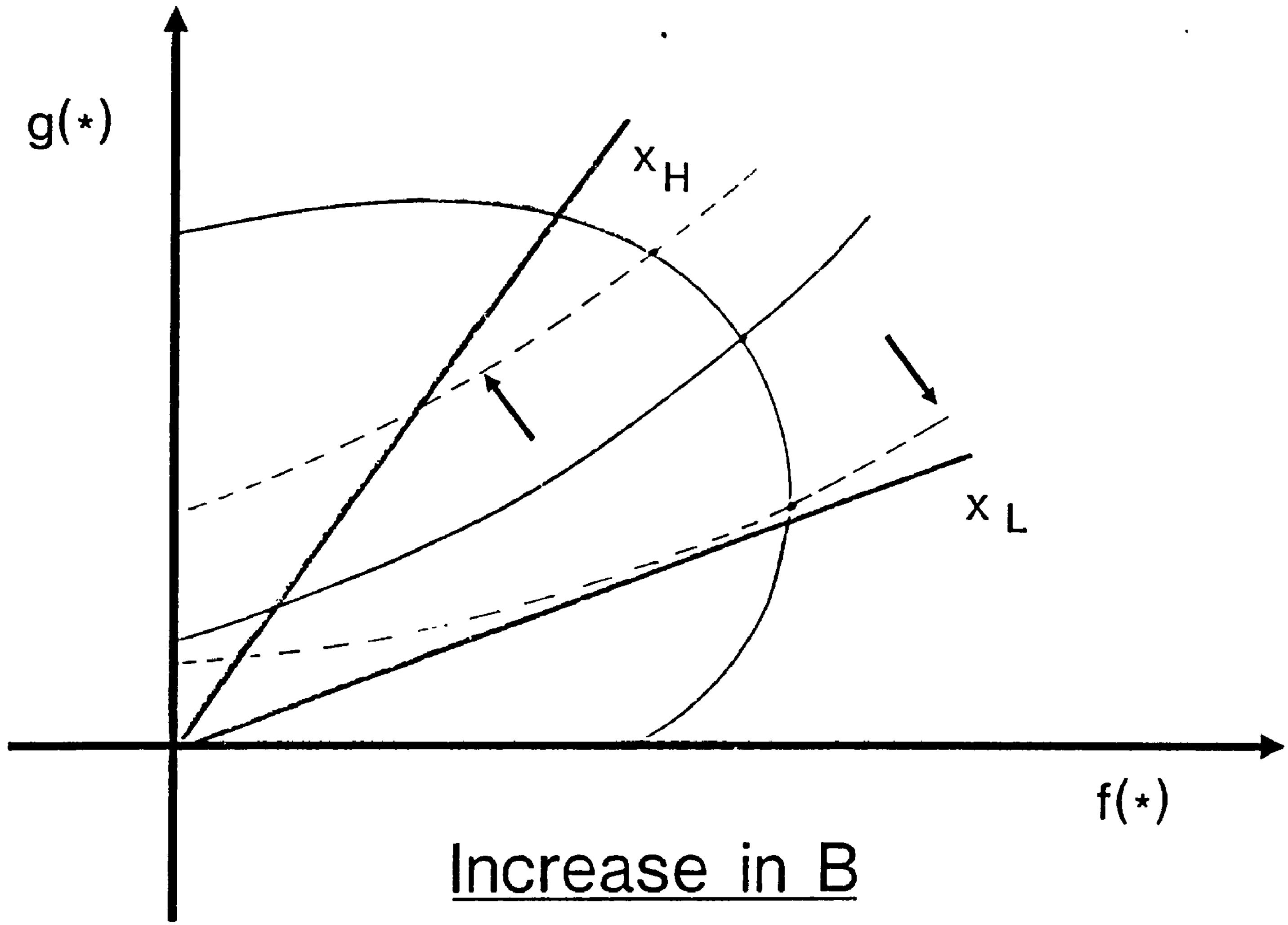
Lobbying Equilibrium 3

Fig.5



Increase in P*

Fig. 6



Increase in B

Fig. 7

Appendix 3.A

The algebraic expression of equation (3.7) is shown in this appendix.

We substitute equation (3.6) into (3.5) and set $\sigma_M = (\alpha_M^{\alpha_M}\delta_M^{1-\alpha_M})^{-1}$, one can get the following expression:

$$P^* B^{\delta_M} f(L_M^l)^{\alpha_M+\delta_M-1} g(L_A^l)^{1-\alpha_M} (f(L_M^l) + g(L_A^l))^{\alpha_M-\delta_M-1} K_M^{1-\delta_M-\alpha_M} = W^*.$$

Appendix 3.B

We show the algebraic expression of equation (3.9) in this appendix. The derivation is similar to what we did for equation (3.7).

Set $\sigma_A = (\alpha_A^{\alpha_A}\delta_A^{1-\alpha_A})^{-1}$, one can get the following expression:

$$B^{\delta_A} f(L_M^l)^{1-\alpha_A} g(L_A^l)^{\alpha_A+\delta_A-1} (f(L_M^l) + g(L_A^l))^{\alpha_A-\delta_A-1} D_A^{1-\delta_A-\alpha_A} = W^*.$$

Appendix 3.C

In this appendix, the algebraic expression equation (3.10) is shown.

$$\begin{aligned} EW(L_M^l, L_A^l) &= P^* B^{\delta_M-\delta_A} g(L_A^l)^{2-\alpha_A-\alpha_M-\delta_A} f(L_M^l)^{\alpha_M+\alpha_A+\delta_M-2} K_M^{1-\delta_M-\alpha_M} \\ &\quad -(f(L_M^l) + g(L_A^l))^{\alpha_A-\alpha_M+\delta_M-\delta_A-2} D_A^{1-\delta_A-\alpha_A} \end{aligned}$$

Appendix 3.D

We show the properties of EW = 0 in this appendix. First, we show how this curve responses to a change in L_M^l.

$$\begin{aligned}\frac{\partial EW}{\partial L_M^l} &= P^* B^{\delta_M-\delta_A}(f(L_M^l))^{\alpha_A+\alpha_M+\delta_M-3}(f(L_M^l)+g(L_A^l))^{\alpha_M+\alpha_A+\delta_A-\delta_M-1} \\ & K_M^{1-\alpha_M-\delta_M}[(\alpha_A+\alpha_M+\delta_M-2)g(L_A^l)+(2\alpha_M+\delta_A-2)f(L_M^l)] \\ & < 0\end{aligned}$$

Second, we show how this curve responses to a change in L_A^l.

$$\begin{aligned}\frac{\partial EW}{\partial L_A^l} &= (f(L_M^l))^{\alpha_A+\alpha_M+\delta_M-2}(f(L_M^l)+g(L_A^l))^{\alpha_M-\alpha_A+\delta_A-\delta_M-1}\bar{K}^{1-\alpha_M-\delta_M} \\ & \left[\frac{(2-\alpha_A-\alpha_M-\delta_A)f(L_M^l)+(2-2\alpha_A-\delta_M)g(L_A^l)}{g(L_A^l)}\right]P^* B^{\delta_M-\delta_A} \\ & > 0\end{aligned}$$

Appendix 3.E

We provide the proof of lemma 3.1 in this appendix.

Before further analysis, we can define the following two functions which can help us to understand the behavior of equations (3.11) and (3.12). For $x \in [0, \infty)$:

$$f_1(x) = (1+\frac{\alpha_M}{\delta_M})x - \frac{\alpha_A x^3}{\delta_A} + \frac{2\alpha_M}{\delta_M}$$

$$f_2(x) = (1+\frac{\alpha_A}{\delta_A})x^2 + \frac{2\alpha_A x^3}{\delta_A} - \frac{\alpha_M}{\delta_M}$$

Lemma A.3.1: If C2 : $\frac{\alpha_A}{\delta_A} < 1$, there exists a unique x_H such that

1) If $x < x_H$, $f_1(x) > 0$;

2) If $x > x_H$, $f_1(x) < 0$;

3) $x_H > 1$.

Proof:

By taking derivative of $f_1(x)$ with respect to x, one can get the following results:

$$f_1'(x) = \frac{\delta_M + \alpha_M}{\delta_M} - \frac{3\alpha_A x^2}{\delta_A}$$

Define $\bar{x} = \left[\frac{(\delta_M + \alpha_M)\delta_A}{3\alpha_A \delta_M}\right]^{\frac{1}{2}}$.

One can show that

$$f_1'(x) \quad \underset{>}{\overset{<}{=}} \quad 0 \quad iff \quad x \quad \underset{<}{\overset{>}{=}} \quad \bar{x}$$

and

$$f_1(\bar{x}) = 2(\delta_M + \alpha_M)^{\frac{3}{2}} \delta_M^{-\frac{3}{2}} \delta_A^{\frac{1}{2}} 3^{\frac{1}{2}} + \frac{\alpha_M}{\delta_M} \quad > 0$$

Since $x \in [0, \infty)$, one can find a $\hat{x}$ such that $f_1(\hat{x}) < 0$ and $\bar{x} < \hat{x}$. Since $f_1'(x) < 0 \;\; \forall \;\; x > \bar{x}$ and $f_1(x)$ is continuously differentiable, there exists a unique x_H such that $f_1(x_H) = 0$. One can show that $f_1(1) > 0$ if $\frac{\alpha_A}{\delta_A} < 1$. **Q.E.D.**

Lemma A.3.2: If C3 : $\frac{\alpha_M}{\delta_M} < 1$, there exists a unique x_L such that

1) If $x < x_L$, $f_2(x) < 0$;

2) If $x > x_L$, $f_2(x) > 0$;

3) $x_L < 1$.

Proof:

Taking derivative of $f_2(x)$ with respect to x, we can find that derivative is positive

.

$$\frac{\partial f_2(x)}{\partial x} = (1 + \frac{\alpha_A}{\delta_A})2x + \frac{6\alpha_A x^2}{\delta_A} > 0$$

Since $f_2(0) < 0$ and $x \in [0, \infty)$, one can find a $\hat{x}$ such that $f_2(\hat{x}) > 0$ and also there exists a unique x_L such that $f_2(x_L) = 0$. If $\frac{\alpha_M}{\delta_M} < 1$, one can show that $x_L < 1$.

Q.E.D.

If $x = \frac{g(L_A^l)}{f(L_M^l)}$, one can show the following:

$$\frac{\partial FE}{\partial L_M^l} \quad \underset{<}{\overset{>}{=}} \quad 0 \quad iff \quad f_1(x) \quad \underset{<}{\overset{>}{=}} \quad 0$$

$$\frac{\partial FE}{\partial L_A^l} \gtreqless 0 \quad iff \quad f_2(x) \gtreqless 0$$

From lemma A.3.1 (A.3.2), we find that there is a critical ratio such that for all x larger than this value, the negative (positive) employment effect by an increase in L_M^l (L_A^l) will dominate. However, the positive (negative) employment effect will dominate if the ratio is smaller than the critical value. From the definitions of f_1 and f_2 and using implicit function theorem, we can see how the values of x_H and x_L are affected by parameters.

1) $\frac{dx_L}{d\alpha_M}, \frac{dx_H}{d\alpha_M} > 0$

2) $\frac{dx_L}{d\alpha_A}, \frac{dx_H}{d\alpha_A} < 0$

3) $\frac{dx_L}{d\delta_M}, \frac{dx_H}{d\delta_M} < 0$

4) $\frac{dx_L}{d\delta_A}, \frac{dx_H}{d\delta_A} > 0$

We provide the intuition behind above results. An increase in α_M or a decrease in δ_M (increase in α_A or decrease in δ_A) increases the negative (positive) employment effect by an increase in L_A^l and increases the positive (negative) employment effect by an increase in L_M^l.

Appendix 3.F

We show the sign of J is negative provided C1 is assumed.

$$\begin{aligned}
J &= \frac{\partial EW}{\partial L_M^l}\frac{\partial FE}{\partial L_A^l} - \frac{\partial EW}{\partial L_A^l}\frac{\partial FE}{\partial L_M^l} \quad \Big|_{EW=FE=0} \\
&= (f(L_M^{l*}))^{\alpha_A+\alpha_M+\delta_M-3}(f(L_M^{l*}) + g(L_A^{l*}))^{\alpha_M+\alpha_A+\delta_A-\delta_M-1}K_M^{1-\alpha_M-\delta_M} \\
&\quad \left\{\frac{\alpha_A}{\delta_A}\frac{g(L_A^{l*})}{f(L_M^{l*})}\left[(2\alpha_M + \delta_M - 2)\frac{g(L_A^{l*})}{f(L_M^{l*})} + (4\alpha_M + \delta_M + \delta_A - 4)\right]\right. \\
&\quad +\frac{\alpha_M}{\delta_M}\left[(2\alpha_A + \delta_A - 2)\frac{f(L_M^{l*})^2}{g(L_A^{l*})^2} + (4\alpha_A + \delta_M + \delta_A - 4)\frac{f(L_M^{l*})}{g(L_A^{l*})}\right]
\end{aligned}$$

$$+(\alpha_A+\alpha_M+\delta_M-2)\frac{g(L_A^{l*})}{f(L_M^{l*})}+(\alpha_A+\alpha_M+\delta_M-2)\frac{f(L_M^{l*})}{g(L_A^{l*})}$$
$$+(1+\frac{\alpha_A}{\delta_A})(2\alpha_M+\delta_A-2)+(1+\frac{\alpha_M}{\delta_M})(2\alpha_A+\delta_M-2)\Big\}P^*B^{\delta_M-\delta_A}$$
$$< \quad 0$$

Appendix 3.G

We show the sign of $\frac{d\lambda_M}{dP^*}$ is positive if C1 is assumed.

$$\frac{d\lambda_M}{dP^*}=-\frac{1}{J}\frac{\partial EW}{\partial P^*}\frac{\left(g(L_A^{l*})\frac{\partial FE}{\partial L_A^l}+f(L_M^{l*})\frac{\partial FE}{\partial L_M^l}\right)}{(f(L_M^{l*})+g(L_A^{l*}))^2} \quad > \quad 0$$

Since

$$g(L_A^{l*})\frac{\partial FE}{\partial L_A^l}+f(L_M^{l*})\frac{\partial FE}{\partial L_M^l} = \left(1+\frac{\alpha_M}{\delta_M}\right)f(L_M^{l*})+\left(1+\frac{\alpha_A}{\delta_A}\right)g(L_A^{l*})$$
$$+\frac{\alpha_M f(L_M^{l*})^2}{\delta_M g(L_A^{l*})}+\frac{\alpha_A g(L_A^{l*2})}{\delta_A f(L_M^{l*})} \quad > \quad 0$$

Appendix 3.H

We show the sign of $\frac{dL_M^*}{dP^*}$ is positive provided C1 is assumed.

$$\frac{dL_M^*}{dP^*} = -\frac{1}{J}\frac{\partial EW}{\partial P^*}\frac{\alpha_M}{\delta_M}\left[\frac{\partial FE}{\partial L_A^l}+f(L_M^{l*})\frac{\left(2g(L_A^{l*})\frac{\partial FE}{\partial L_A^l}+f(L_M^{l*})\frac{\partial FE}{\partial L_M^l}\right)}{g(L_A^{l*})^2}\right]$$
$$> \quad 0$$

Since

$$\frac{\partial FE}{\partial L_A^l} + f(L_M^{l*})\frac{\left(2g(L_A^{l*})\frac{\partial FE}{\partial L_A^l}+f(L_M^{l*})\frac{\partial FE}{\partial L_M^l}\right)}{g(L_A^{l*})^2}=\frac{1}{g(L_A^{l*})^2}\Big[f(L_M^{l*})^2$$
$$+\left(1+\frac{4\alpha_A}{\delta_A}\right)g(L_A^{l*})^2+\left(1+\frac{\alpha_A}{\delta_A}\right)2g(L_A^{l*})f(L_M^{l*})+\frac{2\alpha_A g(L_A^{l*})^3}{\delta_A f(L_M^{l*})}\Big]$$
$$> \quad 0$$

Appendix 3.I

We show the sign of $\dfrac{dL_A^*}{dP^*}$ is negative if C1 is assumed.

$$\frac{dL_A^*}{dP^*} = \frac{1}{J}\frac{\partial EW}{\partial P^*}\frac{\alpha_A}{\delta_A}\left[\frac{\partial FE}{\partial L_M^l} + g(L_A^{l*})\frac{\left(2f(L_M^{l*})\frac{\partial FE}{\partial L_M^l} + g(L_A^{l*})\frac{\partial FE}{\partial L_A^l}\right)}{f(L_M^{l*})^2}\right] < 0$$

Since

$$\begin{aligned}\frac{\partial FE}{\partial L_M^l} \quad + \quad g(L_A^{l*})\frac{\left(g(L_A^{l*})\frac{\partial FE}{\partial L_A^l} + 2f(L_M^{l*})\frac{\partial FE}{\partial L_M^l}\right)}{f(L_M^{l*})^2} &= \frac{1}{f(L_M^{l*})^2}\Bigg[g(L_A^{l*})^2 \\ &+\left(1+\frac{4\alpha_M}{\delta_M}\right)f(L_M^{l*})^2 \\ &+\left(1+\frac{\alpha_M}{\delta_M}\right)2g(L_A^{l*})f(L_M^{l*}) + \frac{2\alpha_M f(L_M^{l*})^3}{g(L_A^{l*})\delta_M}\Bigg] \quad > \quad 0\end{aligned}$$

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